THE ENGINEER

JANUARY 22, 1954

Sir Ernest Benn, Bart., C.B.E.

SIR ERNEST BENN, whose death occurred at Oxted, Surrey, on Sunday, January 17th, was well known to many engineers by his long career in trade and technical publishing, and by his enthusiasm for the work of the Society of Individualists. Sir Ernest, who was seventy-eight, was the second baronet. He was educated at the City Central Foundation School in London, and as a youth entered the office of the *Cabinet Maker*, which had been started by his father. Sir Ernest has said himself that he certainly began in a blind alley, with no definite duties except to do what he was told, with no training, and with few prospects except such as he could find for himself! Nevertheless, for more than fifty years Sir Ernest applied his energy and his ability to the development of the publishing business which bears his name, and to many other activities concerned with economic and social affairs. He was an able writer, as is revealed by such books as *Confessions of a Capitalist* and *Happier Days*, and a number of others on economic, political and industrial matters which came from his pen. Sir Ernest was a founder member and a past president of the Society of Individualists, a society which frequently provided a platform for the exposition of his conviction that the "main cause of the majority of our troubles is the mania for invoking public action, for taking money which would be productive and useful if left in private hands, and rendering it sterile and useless in the dead hand of the state machine." As well as being a Freeman of the City of London, Sir Ernest was High Sheriff of the County of London in 1932.

Lloyd's Register of Shipping

LAST week Lloyd's Register of Shipping issued the 1954 edition of its Register Book, including statistical tables based on the entries at July, 1953. The notes on the 1953 statistical tables include a list giving the gross tonnage of the principal fleets of the world together with an indication of the amount of increase or decrease of the totals of individual countries compared with 1952. At 93,352,000 tons the world total shows an increase of 3,171,000 tons and the returns show that the following countries had the largest increases: Liberia 536,000 tons; Japan 463,000 tons; Norway 357,000 tons; Germany 352,000 tons, and Sweden 244,000 tons, while the increase for the British Commonwealth, which had a total of 22,356,000 tons, was 29,000 tons. Compared with 1939 the outstanding increases were: the United States of America 15,875,000 tons; Panama 3,189,000 tons; Liberia 1,434,000 tons and Norway 1,429,000 tons; while substantial decreases were still recorded for Germany, 2,733,000 tons, and Japan, 2,379,000 tons. The preponderance of ships in the 6000 tons to 8000 tons group continues to reflect the influence of war-time building although most of the ships are not in service. Most of the post-war tonnage falls in the group 10,000 tons to 15,000 tons, a fact mainly due to the preponderance of oil tankers, which form 78 per cent of the ships of this size under ten years of age. Since 1952 the world total of oil tankers has increased by 1,975,000 tons to 21,964,000 tons, representing 24 per cent of the grand total, compared with 22 per cent of a year ago. A list of the oil tanker fleets shows that the largest are: Great Britain and Northern Ireland 4,656,000 tons; U.S.A. 4,461,000 tons, and Norway 3,362,000 tons. The proportion of the world tonnage represented by motorships increased by 2 per cent to 31 per cent but there were wide variations between different countries, the percentage of motorships in Norway, Sweden and Denmark being 79, 76 and 76, respectively, while the percentages for Greece and the U.S.A. are 3·9 and 4·4, respectively. The notes indicate that there has been a further increase in the use of oil as fuel to 87 per cent and the 13 per cent representing the tonnage burning coal compares with 45 per cent in 1939 and 97 per cent in 1914. At the end of June, 1953, 9948 merchant ships with an aggregate tonnage of 39,350,500, representing nearly half of the effective world total were entered in the Register Book to the Society's classification.

International Cargo Handling Co-ordination Association

THE annual progress report for 1953 of the International Cargo Handling Co-ordination Association was issued last week. After commenting upon the post-war difficulties in the turn round of shipping which has not matched the improved speed and economy of ships, the report goes on to recall the inaugural meeting of the Association in 1951, which had for its purpose the co-ordination of experience and knowledge in cargo handling. In the intervening two years the number of delegates has increased from seventy to nearly 400, representing thirty-eight countries, in many of which national committees have been formed. The report lists the services of the Association under five main headings and proceeds to comment upon the technical meeting in Rotterdam and Amsterdam, the symposiums on timber handling and palletised loads in London. Meetings in Rotterdam, Paris and Naples are announced to take place during the first six months of this year, while a Bulk Cargo Symposium is planned to be held in Liverpool in October. The consultative service is touched upon, followed by a note upon publications, particular reference being made to the handbook published, as an elementary guide for those handling dangerous goods, by the Belgian committee. In the report mention is made of the practical developments to speed up the turn-round of ships, such as the experiments in handling bulk sugar, the unit handling of hides and timber and palletisation. Training in the handling of cargo is another item dealt with and its importance is emphasised while attention is drawn to the training scheme instituted by the Netherlands Shipping Federation South at the Dockers School in Rotterdam and to the training given to ship's officers in the United States of America.

Galvanising Techniques in the U.S.A.

THE Organisation for European Economic Co-operation has just published the report of Technical Assistance Mission No. 78, which is entitled "Galvanising Techniques in the U.S.A." This report is the work of a group of twenty-nine experts connected with the galvanising industry in twelve European countries. It is intended to meet the diverse needs of firms, varying widely both in process details and efficiency, which comprise the Western European galvanising industry. It was decided at the outset that although it might involve some duplication of the work done by the Anglo-American Council on Productivity in the preparation of the report on "Hot Dip Galvanising of General Work," the mission should not confine itself to continuous process galvanising. The mission, therefore, covered all four branches of the industry, including the galvanising of finished products as well as the specialised galvanising of sheet and strip, wire and wire products, and tubes. In connection with the galvanising of sheet and strip it is pointed out in the report that substantial advances in the European sheet galvanising industry will not be made until steps are taken to lessen the diversity of product specifications. In parts of Europe it will not be possible to install larger plants, running more economically, until a number of countries agree to standardise their requirements. In connection with tube galvanising the team considered that higher productivity could best be achieved by operating all the equipment continuously, by increasing standardisation, to allow the smaller plants to achieve longer runs, and by educating workers to appreciate the advantages of increased production rates. The members of the team were impressed by the high productivity of the United States plants producing wiped wire which accounted for a very high proportion of the output of galvanised wire. Owing to various conditions, however, a large output of wiped wire was not required in Europe. No new galvanising processes for wire were seen and the productivity for the manufacture of fully galvanised wire was no higher than in many European factories. In connection with finished products it was found that the high productivity achieved in many American plants showed the benefits of standardisation in a large market. The demand for high output had perhaps led to a somewhat poorer finish on the articles, but there was no evidence that the intrinsic value of the coatings was any less, nor corrosion resistance any lower, than that generally obtained with the higher finished work turned out by the better works in Europe. The team considered that if amongst other things European firms improved their material handling methods, there was closer co-operation between the galvaniser and the users, and further standardisation, many European plants could double or treble their output and attain a production approaching that of the plants in the United States.

Metropolitan Water Board's Report

THE annual report of the Metropolitan Water Board, covering the year ended March 31, 1953, has been published this week. It is the fiftieth report of its kind and consequently it contains some account of the Board's golden jubilee which was celebrated last spring, and to which reference was made in our issue of April 3, 1953. Dealing with the year 1952–53, the report says that the total volume of water distributed by the Board from all sources was 118,658·6 million gallons, the average daily supply per head of the population in the area covered being 49·44 gallons. At the end of the year the Board had 302 engines in use, aggregating 67,789 h.p., which included twelve portable pumps, aggregating 1923 h.p., but excluded subsidiary engines and the equipment of small auxiliary works. The fuel consumed for pumping purposes during the year was 118,727 tons of coal, 54 tons of coke, 1,278,363 gallons of oil and 51,256,458 units of electricity. The total length of mains in the Board's area on March 31st last was 8,547·67 miles, the length of new mains laid during the year being 43·01 miles. Of the new mains installed, 13·68 miles, or 31·8 per cent, were north of the Thames, and 29·33 miles, or 68·2 per cent, were south of the Thames. In a section dealing with water purity, the report says that throughout the year, the Board's supply was maintained at the usual high standard. Of 11,394 samples of water being pumped into supply from filtration stations and wells, 99·8 per cent contained no *Bact coli* in 100 ml. Samples are collected daily at the works at each stage of purification, so that the Board's engineers may be given early warning of any falling off in efficiency or of the occurrence of adventitious pollution. During the period reviewed by the report, the physical, chemical, bacteriological and biological tests involved the collection of 93,339 samples of water, a task which was carried out by a staff of sixteen trained collectors equipped with the requisite sampling apparatus.

High Temperature Turbine Machinery for Marine Propulsion

No. I—STEAM TURBINES

By T. W. F. BROWN, D.Sc., S.M., M.I.E.E.*

In his Thomas Lowe Gray lecture before the Institution of Mechanical Engineers on Friday, January 15th, the author opened by examining present practice in high temperature land and marine steam turbine design. In the section of the lecture reprinted below he explored the possibilities of future development discussing reheating by steam, gas and liquid metal, assessing maximum gains and giving special attention to future marine propulsion turbines.

Considerations Controlling Upper Limit of Steam Temperature

MATERIALS have been tested on the laboratory scale up to 1800 deg. Fah., but it is felt that even in this survey a top metal temperature of 1700 deg. Fah. in the superheater tubes is the best that can be expected in the present state of the art. With this limit a top temperature of steam leaving the superheater of 1500 deg. Fah. has been chosen. When it is clear that a good design can be achieved with a heat drop in the first stage nozzles corresponding to a temperature drop of 100 deg. Fah., the highest temperature of steam impinging on the blading and surface of the rotor is 1400 deg. Fah. The mean temperature in the rotor body is lower than this, since the isothermals in the rotor show heat flowing from the hottest part of the rotor to the cooler parts farther down the expansion, and the temperature at the rotor bore below the first-stage disc will not exceed 1350 deg. Fah. Designs could be suggested which could use the stresses available at the appropriate temperatures in the materials to produce a practicable turbine.

In an earlier section designs of turbines are shown where the glands and bearings are remote from the hottest zone of the turbine. It is also clear that the double-casing design of turbine would be essential. The main outer casing would then only have to deal with temperatures of the order of 1100 deg. Fah., this being the temperature of steam exhausting from the inner casing. Such considerations fix a limit for steam temperatures up to 1500 deg. Fah. at turbine inlet. The effect of up to two stages of reheat at this temperature will also be examined.

Steam Turbine Heat Rates and Efficiencies at High Temperature

Land Turbines.—Information derived from the firms which have helped the author by supplying particulars, and from published sources, is given in Table I. Gross refers to the heat rate per kilowatt-hour of turbines only and net to the overall figure including boiler efficiency and auxiliary requirements. Most turbine manufacturers give the gross figure, and the net is then derived from the boiler efficiency and the appropriate auxiliary system.

Fig. 1 shows the estimated variation of turbine heat rate with steam temperature over the range 850–1500 deg. Fah. for a unit of about 60MW. Curves are shown for cycles without reheat, and with one and two stages of reheat. Six stages of feed heating are assumed, and pressure drops in the reheaters of 5 per cent, which is a practicable value for liquid-metal-coupled reheaters. The assumed variation of steam pressure with temperature is shown on the curve. The numbered points inserted in Fig. 1 are those taken from Table I. Where the points are lower than the curves they are all explainable by some such factor as that the size of the unit is larger than 60MW (the basis of the calculations), or that more stages of feed heating than six are being employed, or that a change has taken place in inlet pressure or vacuum (the basis being 28½in of mercury). As the curves are established by these figures up to 1100 deg. Fah., and as there is little doubt about the thermodynamic properties of steam it is hoped that the curves are sufficiently useful to show trends up to 1500 deg. Fah.

Table II gives the derivation of overall thermal efficiencies from those calculations made on the basis of turbines only.

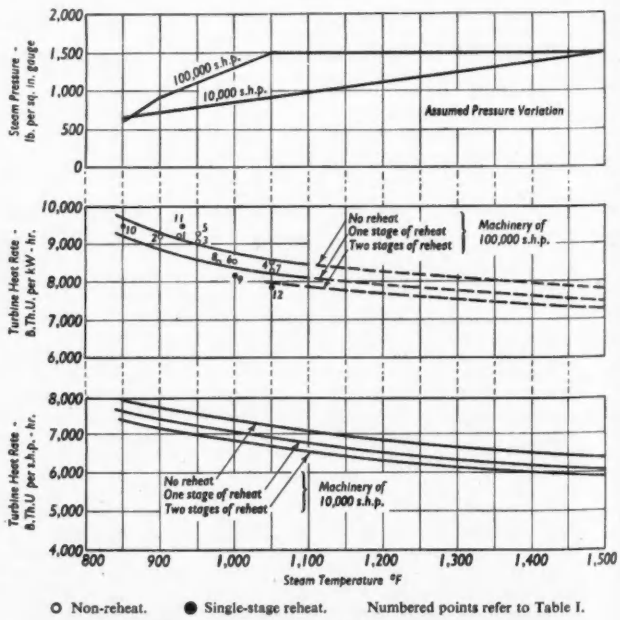
The auxiliary powers for the straight cycle in Table II have been extrapolated from curves given by Finniecombe (1946) and

TABLE II—*Estimated Efficiency of Power Station Machinery of 60MW*

Steam conditions		Thermal efficiency (gross, turbines only), per cent	Auxiliary power, per cent	Boiler efficiency, per cent	Overall efficiency (net), per cent
Lb per sq in gauge	Temperature, deg. Fah.				
600	850 (noreheat)	35·2	4·1	88	29·7
600	850 (plus 1 reheat)	37·1	4·1	88	31·3
1500	1200 (noreheat)	41·6	4·6	88	35·0
1500	1200 (plus 1 reheat)	43·2	4·6	88	36·4
1500	1200 (plus 2 reheats)	44·7	4·6	88	37·7
1500	1500 (noreheat)	44·0	4·0	88	37·3
1500	1500 (plus 1 reheat)	45·8	4·0	88	38·7
1500	1500 (plus 2 reheats)	47·3	4·0	88	40·0

TABLE I—*Summary of Turbine Heat Rates for Power Station Machinery*

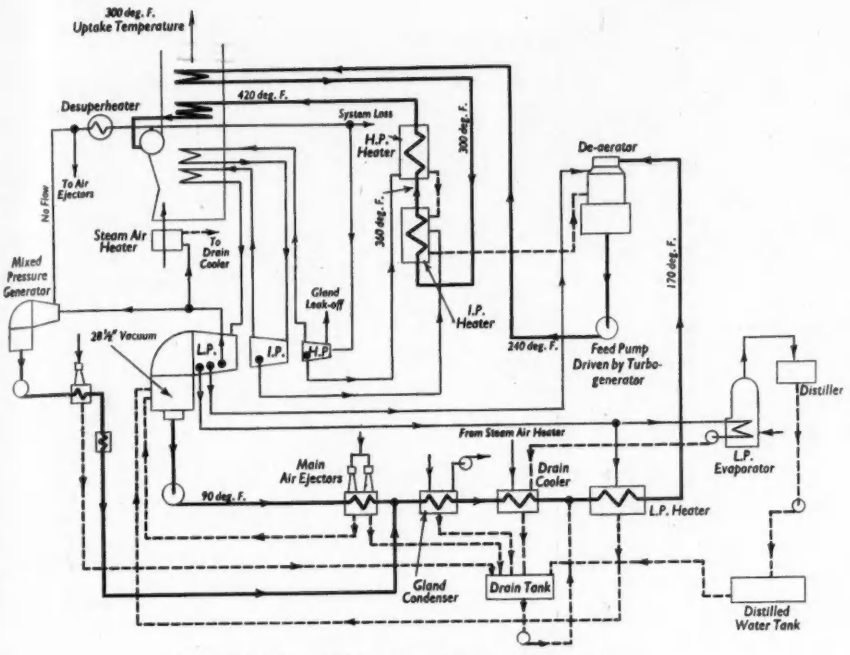
Station	Point on graph (Fig. 1)	Turbine manufacturer	Steam conditions: Lb. per sq in gauge	Steam conditions: Temperature, deg. Fah.	Steam conditions: Inches, of mercury	Stages of feed heating	Feed temperature, deg. Fah.	Capacity, megawatts	Heat rate at most economic rating, B.Th.U. per kW-hr	Source of information
Non-reheat plants										
—	1	C. A. Parsons and Co.	900	925	—	—	—	60	about 9200	Builders
—	2	English Electric Company	900	900	28·7	5	385	60	9224	Builders
—	3	English Electric Company	1250	950	28·86	5	460	60	9042	Builders
—	4	English Electric Company	1500	1050	28·9	6	410	100	8463	Builders
Willesden	5	(1) Metropolitan-Vickers Electrical Company; (2) English Electric Company	1300	950	28·7	6	360	30	(1) 9287; (2) 9302; mean 9295	Clinch (1949)
Essex No. 1	6	General Electric Company	1250	1000	28·5	8	—	100	8500	Renton and Neal (1950)
Sewaren Nos. 2 and 3	7	General Electric Company	1500	1050	28·5	8	453	100	8250	Fairchild (1950)
Dampf Waftwerk Weisweiler, Aachen	8	Brown Boveri and Co.	1550	977	28·25	6	415	150	8500	*Brown Boveri Review* (1953)
Single-stage reheat plants										
—	9	C. A. Parsons and Co.	1500	1000/1000	—	—	—	100	About 8200	Builders
Dunston "B II"	10	C. A. Parsons and Co.	600	850/850	28·75	4	346	50	9460	Howell and Jackson (1953)
Brimsdown "A"	11	Metropolitan - Vickers Electrical Company	1900	930/810	28·7	5	355	53	9407	Clinch (1949)
Philip Sporn	12	General Electric Company	2000	1050/1000	28·5	8	441	141	Net 9270; Gross 7820	Sporn (1948)
Two-stage reheat plant										
Philo	13	General Electric Company	4500	1100/1050/1000	29	7	515	120	Net 8200	*Electrical World* (1953)



○ Non-reheat. ● Single-stage reheat. Numbered points refer to Table I.

Fig. 1—Variation of Heat Rate with Steam Temperature for Machinery of About 100,000 and 10,000 S.H.P.

* Research Director, the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada).



10,000 s.h.p.; 1500 lb per square inch gauge, 1500 deg. Fah.

Fig. 2—Feed Diagram for Double Reheat Installation

assumed to be the same for the reheat cycles as for the straight cycles. This checks very well with the net and gross heat rates given in Table I for the Philip Sporn station with conditions of 2000 lb per square inch gauge, 1050/1000 deg. Fah. and 28½in of mercury.

TABLE III.—*Summary of the Results of Calculations for a Marine Steam Turbine Unit of* 10,000 *S.H.P.*

Conditions			Reheat points	Heat rate		Auxiliary factor (propulsion only)	Thermal efficiency		Fuel rate (propulsion only), lb per s.h.p./hr
Inlet pressure, lb per sq in gauge	Inlet temperature deg. F.	Vacuum, inches of mercury		B.Th.U. per s.h.p./hr.	B.Th.U. per equivalent kW-hr.		Turbines only, per cent	Overall, per cent	
650	850	28½	None	7,941	10,650	1·060	32·1	26·6	0·516
650	850	28½	1	7,596	10,180	1·067	33·5	27·6	0·498
650	850	28½	2	7,423	9,950	1·070	34·3	28·2	0·488
1,100	1,200	28½	None	6,855	9,190	1·069	37·1	30·6	0·450
1,100	1,200	28½	1	6,574	8,820	1·070	38·7	31·8	0·432
1,100	1,200	28½	2	6,383	8,560	1·079	39·9	32·5	0·423
1,500	1,500	28½	None	6,410	8,590	1·077	39·7	32·4	0·424
1,500	1,500	28½	1	6,060	8,120	1·083	42·0	34·1	0·403
1,500	1,500	28½	2	5,926	7,940	1·082	42·7	34·9	0·394

Reheat in all instances to initial temperature.
The column for equivalent heat rate per kilowatt-hour has been added to enable the figures to be compared with those applicable to turbo-alternators already given.

Marine Steam Turbine Units.—Although powers developed by marine steam turbine machinery per shaft are tending to increase, it is still true that the majority of steam turbine sets have an average value of something under 10,000 s.h.p. Calculations similar to those already outlined have been made for turbine machinery of this power. The basic turbine efficiencies used were 0·78 for high-pressure and 0·88 for low-pressure turbines, with suitable adjustments for such factors as pressure and wetness in the low-pressure turbine. A vacuum of 28½in of mercury has been assumed throughout. The turbine heat rates are given in Fig. 1 together with the pressures assumed to be appropriate to the chosen steam temperature. Until turbine construction changes basically, high pressures are not appropriate to small units, since parasitic losses rise in proportion to increase in pressure. However, with a turbine of constant s.h.p., some increase in pressure can be accepted with increase in temperature to maintain constant volumetric flow and hence efficiency.

A summary of the results for the marine set of 10,000 s.h.p. is given in Table III. The auxiliary factor mentioned in the table is the ratio of (efficiency of turbine only × efficiency of boiler)/(overall efficiency). A typical feed cycle diagram, applying to a 1500 lb per square inch gauge, 1500 deg. Fah., double reheat installation, is given in Fig. 2. The boiler efficiency has been taken as 88 per cent throughout with steam air heaters, four-stage feed heat with upper and lower economisers and a mixed-pressure turbo-alternator fitted with a direct-drive feed pump. The evaporator is fed with bled steam. In fact, as much steam has been bled from the turbine as possible. Not only does this enable the cycle to improve by approximating to regenerative feed heating, but it also improves the turbine efficiency. In the high-pressure part of the turbine increased flow improves the blade heights and removal of steam during expansion makes the low-pressure end of the turbine smaller.

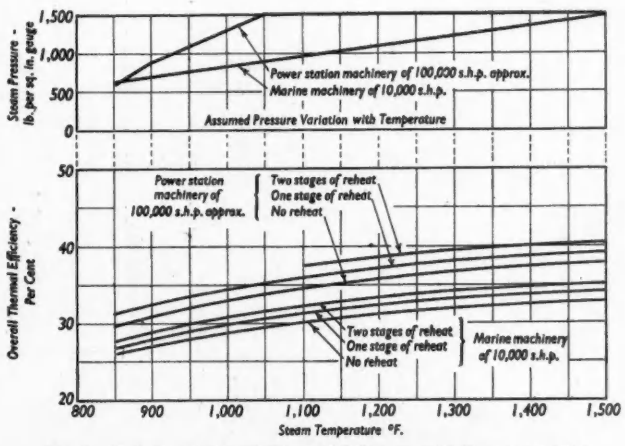


Fig. 3—Variation of Overall Thermal Efficiency with Temperature for Units of About 10,000 *and* 100,000 *S.H.P.*

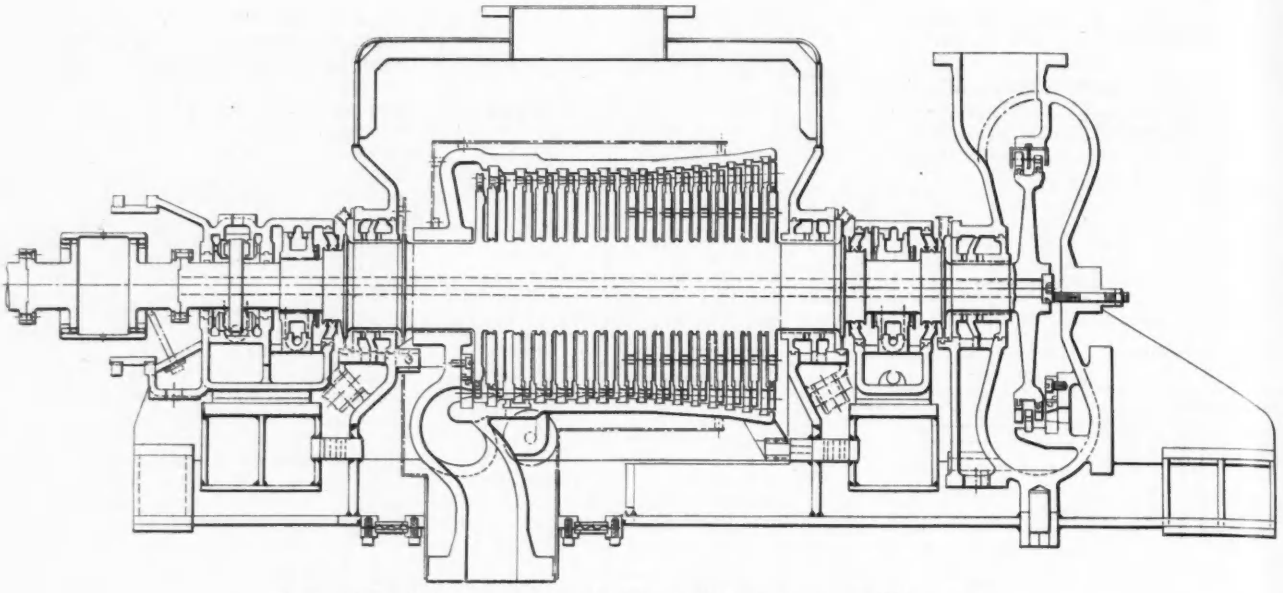
The overall efficiency figures for the sets of 100,000 and 10,000 s.h.p. are shown in Fig. 3.

The calculations were repeated for supercritical working at the 60MW size and a summary is given in Table IV.

The values in the last column of Table IV are very approximate, having been derived from the gross values through multiplying by 0·83 to cover for boiler efficiency and the auxiliary factor. It will be seen that even with this size of unit (100,000 s.h.p.) a pressure of 4500 lb per square inch can only be used with at least one stage of reheat at 1200 deg. Fah. temperature. The improvement in turbine heat rate by pressure change from 1500 lb to 4500 lb per square inch at 1500 deg. Fah. with two reheat points is about 6 per cent and the effect on the overall thermal efficiency will be somewhat less owing to the effect of the auxiliary factor. This pressure in marine use could only be considered for the one or two high-powered ships which may be built in the future. Supercritical pressure calculations have not been made for a set of 10,000 s.h.p., as they are not realistic with present constructional knowledge. From these considerations it would appear that the improvement possible in marine turbines of 10,000 s.h.p. using pressure of 1500 lb per square inch, temperature of 1500 deg. Fah., and two reheat points over simple expansion from 650 lb per square inch, 850 deg. Fah., is of the order of 24 per cent in the fuel consumption for propulsion only.

Some Practical Considerations in the Marine Use of High-Temperature Steam

Boilers.—With the related increase in pressure and temperature, boiler drums would tend to be reduced or eliminated. The suggested type of boiler would have pressure combustion and high gas speeds. The Velox boiler has, in fact, such characteristics. The last expansion of the exhaust gases through a turbine would enable reasonable boiler efficiencies to be obtained without unduly low temperatures at the air heaters which, particularly at part load, have been found to lead to fouling and corrosion. A section of the economiser could also be eliminated. At a pressure ratio of 3·5 the temperature drop through the gas turbine driving the air charging blower would be about 230 deg. Fah., which means that the gas leaving the boiler could have a temperature of, say, 500 deg. Fah. with a temperature at funnel base of 270 deg. Fah. The type of gas turbine would be the simplest possible, a common rotor carrying the centrifugal compressor supplying air to the registers and the centripetal turbine. No high temperature problems would be involved. Great experi-



Steam conditions, 600 lb per square inch gauge, 950 deg. Fah., 28½in of mercury ; speed, 3980 r.p.m.

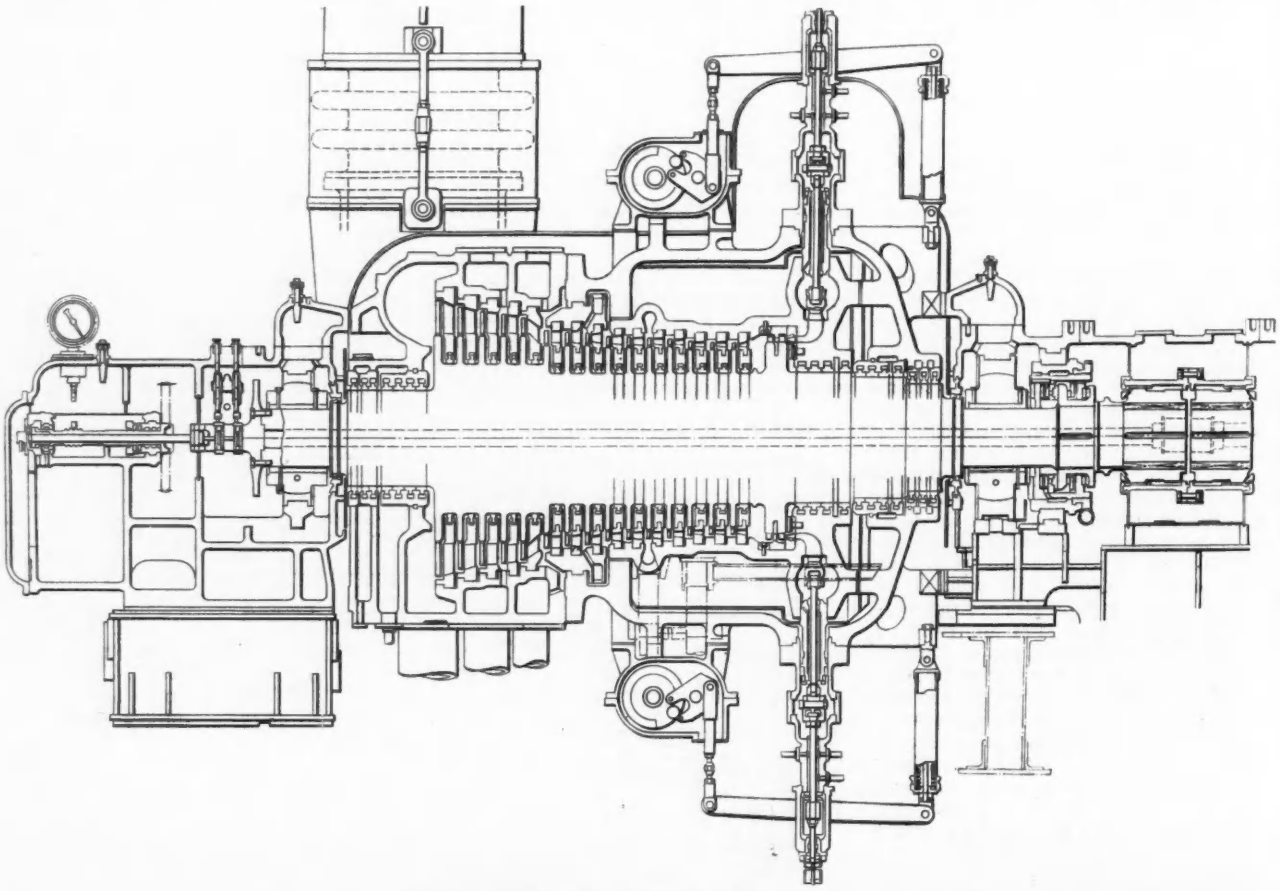
Fig. 4—High-Pressure Turbine for Pametrada Installation of 12,500 *S.H.P.*

ence has already accumulated in operating gas turbine combustion chambers at the pressure of 3·5 atm. with residual fuel with a heat release of the order of $2{\cdot}5\times10^6$ B.Th.U. per cubic foot per atm. per hour leading to a small furnace. This heat release can be associated with high boiler efficiencies when combined with a gas turbine.

Superheaters.—In regard to the highest temperatures in the steam cycle, the superheater tubes are the first part in the installation to be really hot apart from refractories in the furnace. Possible materials have already been referred to. It is clear, however, that vanadium attack on high-temperature alloys is likely to show up in the same way as has already appeared in the running of gas turbines on residual oils with an inlet temperature of 1250 deg. Fah. This effect is discussed below in the section on residual fuel burning.

The Research Committee on High-Temperature Steam Generation of the American Society of Mechanical Engineers is studying the behaviour of superheater tubing materials in combustion atmospheres at 1350 deg. Fah. at the Battelle Memorial Institute. The Naval Boiler and Turbine Laboratory at Philadelphia has also a similar programme to examine first the effect of temperature alone, then high sulphur content in the fuel followed by the addition of vanadium and other ash constituents. Purdue University are examining heat transfer rates as affected by the formation of internal and external films.

Two progress reports—one by Ely and Eberle (1952) (giving the results of over 4000 hours of service, with 500 hours at 1250 deg. Fah. or higher and 1600 hours at 1200 deg.



Steam conditions, 1500 lb. per square inch gauge, 1050 deg. Fah.

Fig. 5—High-Pressure Turbine for Meaford Power Station (British Thomson-Houston Company)

Fah. or higher), and the other by Slunder, Hall and Jackson (1953)—have already appeared. It will be seen that if research work in the United States can speed progress

TABLE IV.—*Summary of Calculations of Heat Rates for a 60MW Size of Unit*

Steam conditions		Heat rate (turbines only), B.Th.U. per kW-hr	Condition at exhaust	Thermal efficiency (gross), per cent	Approximate overall efficiency (thermal) per cent
Lb per sq in gauge	Temperature, deg. Fah.				
4500	850 (no reheat)	8860	27·3 per cent wet	38·6	32
4500	850 (plus 1 reheat)	8300	14·7 " "	41·2	34
4500	850 (plus 2 reheats)	7970	7·3 " "	43·0	35
4500	1200 (no reheat)	7830	15·6 " "	43·7	36
4500	1200 (plus 1 reheat)	7510	7·3 " "	45·5	38
4500	1200 (plus 2 reheats)	7290	0·3 " "	47·0	39
4500	1500 (no reheat)	7400	9·8 " "	46·2	38
4500	1500 (plus 1 reheat)	7100	1·0 " "	48·0	40
4500	1500 (plus 2 reheats)	6840	120 deg. Fah. superheat	50·0	41

Reheat in all instances to initial temperature ; vacuum of 28½in of mercury.

(2) Gas reheat where steam is led from the turbine through a section of the boiler and reintroduced to the turbine. This is suitable for one stage of reheat in marine use in the present state of the art, but, in general, space requirements in a ship would not permit the accommodation of four sets of such high-temperature steam pipes in addition to the main steam pipe if two-stage reheating were required.

(3) Recent developments in the use of liquid metals (such as sodium and sodium-potassium alloy) as heat transfer fluids in the development of nuclear power plants have opened up the possibility of their use as reheating media in steam turbine plant. The liquid metal would transfer heat from a heater section in the boiler to a heat exchanger adjacent to the turbine. This would eliminate the large hot steam pipes between turbine and boiler and replace them by the much smaller pipes carrying liquid metal. Thus two stages of reheat would become feasible in marine use and pressure drops on the steam side could be limited to, say, 5 per cent of the pressure head with a compact design of reheater.

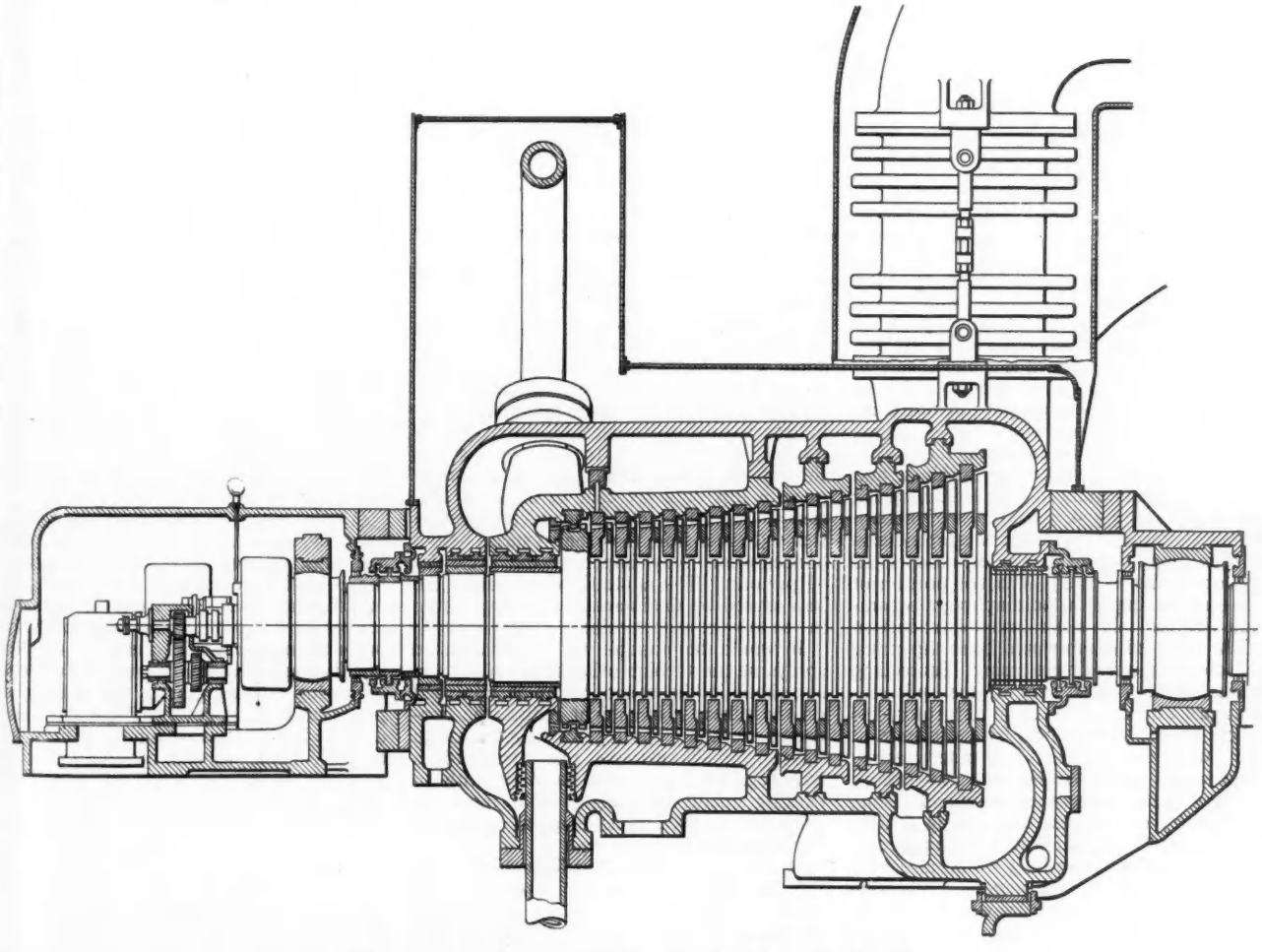
Circulation of the liquid metal requires little power. Even at inlet conditions of 600 lb per square inch and 950 deg. Fah. with four stages of feed heating, the gain due to liquid metal reheating would be 8 per cent, a figure which might well justify the increased cost and complexity of the liquid metal circuit. Mechanically, reheat would reduce moisture in the low-pressure stages and would permit higher blade speeds, without erosion being an important factor. Continuous reheating in the turbine, using liquid metal in the fixed blades or diaphragms of the turbine, is unlikely to be used, since too little area is available in such parts for heat transmission to enable appreciable gains to be achieved. Special precautions would, of course, be necessary to prevent the liquid metal from coming into contact with air or water, but successful operation of pilot plants in Britain and the United States proves that the difficulties can be overcome. In any event high superheated steam at high pressure is itself a dangerous fluid.

Design data and experience are given in Brooks and Rosenblatt (1952), and in the papers given by Hayden (1953), Perkins (1953), and Boadle (1953) at a conference at the Atomic Energy Research Establishment, Abingdon, in May, 1953.

Turbines.—At the higher temperatures the use of the temperatures examined in the paper is not too far away.

Reheating.—Reheating can be performed in three ways :—

(1) Steam reheat, as used in the " Venore " (Robinson and Worthen, 1946). With an initial temperature of about 1000 deg. Fah. this form of reheating would be useless, since the steam reheaters can only heat up the turbine steam to about the saturation temperature corresponding to the initial boiler pressure if this forms the supply of heating steam. It is clear, however, that a self-contained heating circuit can be built into the boiler with a higher pressure than the steam supply to the turbines. Even so, however, the saturated temperature at critical pressure is only 705·4 deg. Fah.



Steam conditions, 1500 lb per square inch gauge, 1050 deg. Fah.; output, 100MW

Fig. 6—High-Pressure Turbine for Castle Donington Power Station (Metropolitan-Vickers)

explored in this lecture, astern turbines would not be used since the special piping, valves, and astern turbine casings would cost much more than alternative solutions, apart from the question of sudden heating through the range of temperature involved. The elimination of astern turbines would also enable more stages to be fitted and with the elimination of windage in this element the highest economic vacuum would be somewhat increased. Boiler operation during manœuvring would also be too complicated if attemperation of the steam were attempted. If one may hazard a guess as to the form of high-pressure turbine, it will have a double casing with end assembly of the inner portion held together by longitudinal bolts in the exhaust space. Owing to their length such bolts would have considerable resilience, and the horizontal joint which is a bad enemy of symmetry—however reduced—would be eliminated. Pipes conveying steam in and out of the inner casing would be arranged flexibly as shown in most of the earlier examples of high-temperature turbines, and the general assembly of the outer casing would be as in Fig. 4. [Examples of modern power station turbine design are reproduced in Figs. 5 and 6 from the earlier, unreprinted section of the lecture.] The hot portion of the inner casing with the diaphragm separation between inlet steam and reintroduction of the reheated steam would be in the centre in a comparatively simple casing. Succeeding stages would be built up of the split diaphragms already in place in the rotor, the whole assembly being held by end clamps at the two exhausts into the outer casing. Supervisory gear to measure and record relative expansion between rotor and casing, eccentricity of casings, &c., during heating up and cooling down, would be required.

As the low-pressure inlet would also be a reheat point when two stages of reheating were designed, the hot inlet would again be in the centre with double-flow exhaust to the end. Two-casing construction would be inevitable. Even at a pressure of 1500 lb per square inch, inlet temperature of 1500 deg. Fah., and two stages of reheat to 1500 deg. Fah., the exhaust temperature at a vacuum of 28½in of mercury is only 367 deg. Fah. For sets larger than 10,000 s.h.p. the value of turbine efficiency would be greater and, consequently, the temperature at exhaust would be less.

Condenser.—In general the condenser would become smaller with the improved steam rates resulting from higher temperatures at any given power. It has already been stated that for the most severe conditions examined the steam exhausting from the low-pressure turbine at a vacuum of 28½in of mercury is superheated. A cooler incorporated as part of the condenser shell may be suggested. It will be found, however, that this heat has to be wasted, since the use of it as a precooler to heat the feed water introduces a net cycle loss of about ¾ per cent owing to the increase in back pressure on the turbine exhaust. For some cases examined, in order to get practicable sizes, ½in of mercury was required to carry the steam through this heat exchanger, which would mean a loss of 2 per cent in the cycle efficiency. This heat exchanger giving heat to the feed water from the exhaust steam before condensation only improves the cycle by 1¼ per cent. This is clearly ruled out by the loss caused by the increase in back pressure in the low-pressure turbine.

It would be possible to use condensate sprays at the turbine exhaust to reduce the superheat in the steam before it impinged on the tubes, which might reduce the condenser surface. The highest temperature in exhaust in the extreme case examined is 367 deg. Fah. and can be dealt with in existing condenser designs. No modifications to the feed cycle diagram shown in Fig. 2 are therefore required.

It may be remarked that for a 10,000 h.p. unit at 1500 deg. Fah. with two stages of reheat a pressure of the order of 15,000 lb per square inch would be required, to have the steam just wet at a vacuum of 28½in of mercury after completing expansion through the turbine. The corresponding figure for the 100,000 s.h.p. turbine would be about 10,000 lb per square inch, owing to the improved turbine efficiency appropriate to the size, which involves less reheat on the expansion line. It will be noted that for the Philo station the corresponding figure is 4500 lb per square inch for a horsepower of about 158,000 at the temperatures already given. These figures indicate the order of magnitude of pressure required to get the exhaust steam into the wet field, but it is possible to deal with the superheated steam in the condenser without it being of undue size.

Gearing.—The unidirectional turbines without astern elements, already postulated, would be coupled to the main line shafting driving the propellers by reduction gearing. Three or more methods of manœuvring (other than turbo-electric propulsion) are available. While the efficiency of a turbo-alternator is practically the same as double-reduction gearing a further energy conversion is required in the motor, which reduces the efficiency to about 92 per cent as against 98 per cent for the gearing.

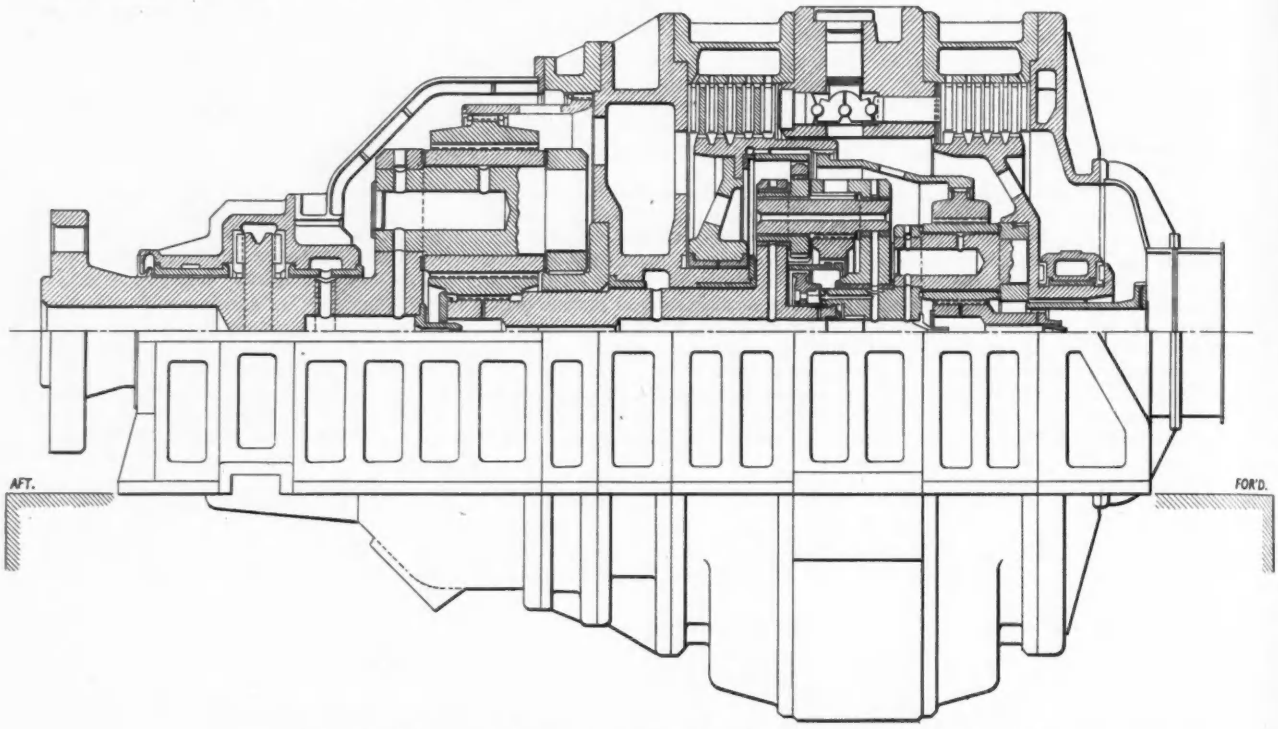


Fig. 7—Epicyclic Marine Reduction and Manœuvring Gear for a Power of About 10,000 S.H.P.

(1) *Controllable Pitch Propeller.*—This solution would best suit two-speed ships, e.g. tugs, trawlers, and minesweepers with the conditions of towing and running free, but such ships are not likely to have high-temperature steam turbine machinery. For ordinary merchant ships the best propeller is one having fixed pitch ; and the complexity of having moving gear in the shafting and propeller boss is best avoided, particularly as the larger boss required with a controllable pitch propeller adversely affects the propeller efficiency.

(2) *Torque Converters.*—With an ahead fluid flywheel efficiencies up to 98·3 per cent have been achieved. The torque converter for astern running is also comparatively simple and efficiencies high enough to give good stopping and backing power have been developed.

(3) *Airflex Couplings and Oil-operated Clutch Gears.*—These have been proved in smaller sets but have an inherent limitation

in regard to power which can be transmitted even when more than one is used simultaneously, particularly at high speed. An idle gear pinion may also be required for reversing, which may give trouble in ahead running without load.

(4) *Epicyclic Reduction and Reverse Gear.*—An example of this design of gear is shown in Fig. 7 for a power of about 10,000 s.h.p. with a reduction ratio of 56 ahead and 40 astern.

The manœuvring is carried out by means of multiple-disc brakes hydraulically applied and cooled by oil. This enables the large inertia load in the shafting, propeller and gears to be taken up without overheating. The size and weight is small ; accurate teeth can be produced on comparatively small machines ; and the general arrangement of the gear suits a tandem arrangement of turbines driving into a single pinion. A single pinion transmitting the whole power of the set means a very large box in the usual arrangement of double-reduction gearing and one of the reversing arrangements mentioned earlier would also have to be incorporated. In a normal design of gearbox, turbine power is applied on two or three high-speed pinions at the first reduction stage and there are many arrangements to spread this power over a larger number of secondary pinions to reduce the size of the main wheel at any required reduction ratio.

Auxiliaries.—These would be largely motor driven with steam turbine driven standby sets. The turbo-generators should be of the mixed-pressure type taking steam from the main turbines at a comparatively low pressure. In this way even in a set of small output the blade heights would be such that efficiency was high. A governor would be fitted to admit attemperated boiler steam through separate nozzles if the steam flow from the main turbine were too little during shut-down, manœuvring, or low-power running. The turbo-generator reduction gearing would drive the feed pump from a pinion and thus the main auxiliary load would be provided at an economical steam rate. Gas turbine generator units are now becoming available and the exhaust would be led into the boiler furnaces, thus eliminating the somewhat bulky heat exchanger sometimes associated with them.

In the previous feed calculations for a 10,000 s.h.p. marine set an equivalent total of 260–350kW was generated for the propulsion auxiliaries and feed pump and is allowed for in the calculations of propulsion-only fuel rate.

Engine-room arrangement would involve having boilers on a shelf over the gearing at the aft end of the engine-room to keep steam piping to a minimum consistent with flexibility. This arrangement would give good hairpin bends in the vertical legs and good drainage arrangements.

(*To be continued*)

Trends of Public Service Vehicle Design

(*Contributed*)

THE directions in which the design of the public service vehicle are likely to develop depend, on the one hand, upon user's requirements, i.e. the circumstances and conditions under which the vehicles are called upon to operate, and, on the other hand, upon the progress of technical refinement and invention. A survey of the likely trends of design, reflecting the opinions and preferences of individual users as well as the developments which the manufacturers have in mind, was recently given in an interesting paper, presented in Madrid by Mr. A. A. M. Durrant, C.B.E., M.I.Mech.E., to the International Union of Public Transport. In this paper Mr. Durrant, who is Chief Mechanical Engineer (Road Services) of London Transport Executive, made use of answers received to a comprehensive questionnaire which was devised to cover as far as practicable the basic features underlying the design of a lightweight, single-deck bus, following the style of a modern mass-produced automobile. Answers were received from twenty manufacturers and fifty-eight operators in seven countries and sixteen countries respectively. The replies showed a tendency to conservatism on both sides. There was some confusion of thought in so far as advanced results were desired, but the means to achieve them were generally denied through a hesitancy to break away from traditional principles.

It is interesting to consider in the light of the various replies the directions in which the majority of the operators wish to see designs developed. As was to be expected, a reduction in weight was regarded as of major importance, especially by the operating authorities, though some doubt was expressed whether an urban forty-five-seater bus, measuring 30ft by 8ft could be built in lightweight construction to weigh 5 tons or less. There is, further, the desire that floor levels should be reduced in urban vehicles, that passenger access should be improved, and more attention be given to the ease of movement of passengers within the vehicle. The consensus of opinion is that the standards of road performance in respect of acceleration, power and braking should be raised ; that the physical effort of driving should be reduced and driver's visibility improved. It appears that most operators are prepared to reduce the amenities for the passengers by letting more of them stand, and by having less refined seats and furnishing. Though it is difficult to express a general view on the desirable ratio of standing to seated passengers, because it must largely depend upon individual local conditions, any tendency to accept a lowering of the standard of passenger amenities seems to the writer regrettable as such a step might adversely affect revenue-earning ability.

Integral Design

Turning to the ways and means of attaining these desiderata it is encouraging to note the enthusiasm displayed for the integral design of vehicle as distinct from the combination of separate chassis and body. Presumably those in favour of this form of construction accept what is, in effect, a corollary, namely, that a sound integral construction has to be scientifically designed and built and thus lends itself best to quantity production by expert manufacturers to standardised patterns. The recourse to having bodies produced for the chassis by the local body builders will be superseded if a really efficient vehicle is to be obtained at a reasonable cost. The weight factor grows in importance as the cost of fuel increases, whether due to basic increase in cost or taxation. In any case, with the tendency of costs to rise in all directions, it is obvious that economies should be effected wherever possible. The integral construction offers the prospect of saving weight without sacrifices in other directions. The importance attaching to weight reduction can be illustrated in the case of the London bus in respect of which, at prevailing prices and taxation, every 1 lb in weight which can be saved justifies additional expenditure up to 12s. 6d. by reason of the saving which will accrue in respect of fuel consumption.

In considering integral design we should attempt to look at the problem completely *de novo*, decide upon the basic requirements as to dimensions and certain features such as type of propulsion, position of entrance, &c., and work out the simplest and most direct way in which the vehicle can be constructed to meet these requirements. It seems logical, for instance, that the suspension points of the vehicle should as nearly as possible lie beneath the side members of the body because these side members, if the stressed skin construction is employed, can form deep and lightweight girders attached laterally by the floor and roof structures. The latter can be light because their load-carrying function is limited to carrying the weight of the passengers or the roof skin. A wide suspension base will also add considerably to the stability of the vehicle.

Independent Suspension

It is desirable that suspensions should operate independently, because, apart from other considerations, they will then impose the least wracking stresses upon the body shell. This can be achieved in simple fashion at the front—practically all private cars to-day are equipped with independent front suspension—and although the arrangement at the rear is more complicated because the drive has to be transmitted to the back wheels, it should at least be possible to provide a coil spring or torsion bar arrangement, which, whilst not offering completely independent suspension, would nevertheless enable the load to be carried practically at the extreme sides of the vehicle. By substituting coil springs or torsion bars in conjunction with rebound dampers of good and robust design for leaf springs, it becomes possible to design accurately for the desired riding characteristics which, with but little maintenance attention, can be relied upon to remain constant. In addition, reduction of high-frequency vibrations is particularly marked with coil and torsion springs, because they are free from the built-in friction inseparable from leaf springs. This becomes an important factor when contemplating a really scientifically designed vehicle structure, because the reduction of continuous high-frequency vibrations lessens the risk of metal fatigue, so that a more economical factor of safety can be used in the design calculations.

Floor Level

Another important question is that of the floor level. In the case of the double-deck bus it is almost universal to have a one-step platform and then possibly one additional step into the lower saloon, a practice inspired by the need to speed up the boarding and alighting of passengers and thus economise on schedule time. The same need surely applies in the case of the single-decker, and it seems that the time is overdue when the design of this class of vehicle in relation to floor level and number of steps should be

basically modified. There are, of course, several reasons which have led to the adoption of high floors. The under-floor engine is one culprit, and another reason is the insistence of operators on the maximum seating capacity, which has forced designers to raise the floor so that seats can be placed over wheel arches. A compromise should be reached and some reasonable sacrifice should be accepted to permit low floor construction and greater freedom of movement for the passengers.

Engine and Transmission

There is no doubt that the diesel engine is capable of further development in efficiency, smoothness and quietness. But it appears strange that, according to the questionnaire replies, neither operators nor manufacturers in this country seem prepared to make any substantial concessions to weight, for they vigorously oppose the use of a small engine with low torque (and a multiplicity of gear ratios) in favour of an engine with an appreciable increase in torque capacity over present standards, which presupposes an engine of even larger swept volume. They also oppose efforts to obtain more power from a lighter and more compact unit operating on the two-stroke cycle, or having a pressure charger in addition to the normal four-stroke arrangement. They oppose air cooling with its immediate advantages of simplicity and adaptability to extremes of climate and its promise of economy in weight and cost, overlooking the reputedly effective and quiet running engines of this type already in production in Germany. The only change they want to see is the increase of bore diameter in relation to the length of stroke, with a view to following the private car trend towards "square" engines. Despite a desire for increased torque and the operator's objection to higher rotational speeds, all wish for a reduction in weight, but seem unable to offer any really helpful suggestion as to how to achieve this aim. Though all operators were unanimous in their desire for higher standards of road performance, i.e. acceleration, power and braking, no clear indication of these standards could be ascertained, as the figures given for unit of engine capacity per unit of vehicle weight covered a very wide range. Whereas in London an ordinary unblown direct-injection diesel engine of 0·87 litre per ton of gross weight is adequate for all needs, it may well be that where very steep and prolonged gradients have to be climbed, a more powerful engine would be justified. On the other hand, if traffic conditions do not necessitate a very high standard of acceleration and the operator is prepared to accept more frequent gear changing, a smaller capacity engine may prove acceptable and would enable weight and fuel consumption to be reduced.

Closely connected with engine capacity is the important question of the transmission. There seems to be agreement that on relatively long haul services and where the frequency of stopping and starting is not too high, a synchromesh gear—perhaps with power assistance for engagement—plus an overdrive is acceptable. For more intensive working, however, some form of semi-automatic gear is to be preferred; where one-man operation is in vogue, two-pedal control is strongly to be recommended. For the second and third conditions in particular the planetary gear—preferably with an automatic friction clutch—possesses definite advantages; it scores on efficiency and, therefore, economy of fuel consumption, and it offers a simple solution when power units of optional capacity are contemplated. The same basic unit can offer direct finger tip control with or without overdrive, or it can be made fully automatic, but with overriding control if desired, and again with or without overdrive.

Road Safety

There is a general desire to reduce the physical effort of driving, and since this must have a bearing upon the important subject of road safety, it is clearly worthy of serious consideration. The effort of braking and gear changing can and should be reduced to a negligible quantity. Both these operations have, in fact, received attention in most designs; indeed, so much has been done in this direction that it is surprising to find so much physical effort is still often involved in steering the vehicles. It would therefore seem wise if manufacturers would either embody mechanism to provide power-assisted steering or make provision to enable power assistance to be incorporated without necessitating a major modification to their layout. Driving visibility has an important bearing on road safety and should therefore receive every consideration in future designs. It is reasonable to suppose that a driver who is comfortable, working without fatigue and able to see all that he wants to see without awkward blind spots, will be a safer and better driver in all respects. A good deal has already been done towards lightening controls and towards improving their placing and in the provision of comfortable seating, &c. But much remains to be done to improve visibility at close range, and, in particular, visibility generally at night and in rainy weather. Heavy pillars at the front corners of the vehicle, deemed necessary for structural strength, must be materially reduced even to the extent, probably, of curved windscreens and a load-carrying bulkhead behind the driver. It is further essential that all trace of reflection from interior lighting should be completely removed from windscreens and fittings around the driver.

The Future Bus

It is quite possible to envisage the design of a future bus which, if developed over a period of some years, might be capable of affecting quite significantly the economic problems of bus operation. On the other hand, such a conception will remain visionary only, unless it becomes possible to count upon the realistic support of the operating authorities, some of whom would have to modify their present attitude if such an advanced project, which presupposes large-scale standardisation, is to be made a commercial success as far as manufacture is concerned. At present progress is being checked to a certain extent by the failure of the operators to visualise what they actually want, and by the manufacturer's hesitation to take any big step forward lest he should lose sales by failing to meet the individual requirements of his customers. If progress in bus design is to make the strides which are necessary to provide a more economical and efficient unit for city-bus operation, operating undertakings will need to drop their attitude of complacency. They share an important responsibility in the matter of real progress, and upon their outlook depends the prospect of developing a vehicle which will constitute a real advance in reduced cost and increased revenue-earning ability. They should get together and, having decided what is wanted, they should not only clearly define the agreed requirements to the manufacturers, but also accept the vehicles they have defined without making individual demands likely to upset economic quantity production. The alternative is that design will be pressed ahead by the manufacturers on lines which they consider ought to be most suitable to the operators, with the result that the operators will eventually find they have no choice at all and will be obliged to accept what the manufacturers offer them. It is obvious that development in the right direction must depend upon the co-operative effort of both manufacturers and users.

B.I.S.R.A. Photo-Electric Dust Concentration Meter

A photo-electric instrument for providing a continuous quantitative record of dust concentration in blast-furnace gas is being manufactured by Radiovisor Parent, Ltd., 1, Stanhope Street, London, N.W.1, after development work and trials under the guidance of the British Iron and Steel Research Association. With this instrument the gases are monitored at any chosen point in the main. It can be calibrated by normal gravimetric measurements and it can be arranged to give an audible alarm if a predetermined dust level is exceeded.

The instrument consists of four main assemblies: a sampling chamber housing a light source, photo-electric cells and optical system; a valve amplifier with stabiliser, power supplies and setting-up controls; a 7in diameter indicator relay meter incorporating a small contactor for connection to an alarm system, and a continuous 3½in wide strip recorder.

The light source and optical system in the sampling chamber gives a parallel beam of light of uniform intensity which is projected through the actual viewing chamber on to a light trap specially designed to prevent secondary light radiation. The principle of operation is that the presence of dust particles causes light-scatter. When clean air is introduced into the viewing chamber the light-scatter is small and a minimum current is passed by the photo-electric cells. The output from the electronic amplifier is "backed-off" so that in the clean air condition a zero reading is shown on the recorder and meter. Any increase in light-scatter due to dust particles in the sampled gas causes an increase in the photo-multiplier current and a corresponding meter deflection.

The viewing chamber consists of a series of baffles to maintain the cylinder of light, and a glass cylinder with gastight joints: on the outside of the cylinder are the three photo-multiplier cells. The complete unit is suitably insulated to reduce heat losses. The output leads from the photo-multiplier cells and the high-tension and projector lamp supplies are brought to a multi-point insulated plug, from which a flexible cable is taken to the electronic control panel. This panel incorporates the thermionic valve amplifiers and their associated power supplies. Controls are provided for setting the instrument to zero, and the meters are graduated to indicate the necessary circuit characteristics. From the panel an output lead is taken to a 7in diameter flush-mounted meter provided with an auxiliary pointer and a small contactor to operate the alarm at any predetermined dial reading.

When the instrument is in use, the blast-furnace gas is taken from the main, raised above dew point by preheating it with steam coils and fed through the viewing chamber. After recording the dust concentration the air is then either injected back into the gas main by an impeller or exhausted to atmosphere. To prevent aggregation of the particles, the design of the sampling tube incorporates smooth bends, gate valves, and a thin-walled receiving tube. Gas velocities in the main stream are measured, and the flow rate in the sampling by-pass controlled by an orifice plate to ensure that a correct comparative reading of the dust concentration is obtained.

Timbers for House Building.—The Timber Development Association has compiled a booklet, *Timbers for House Building*, in which, under the two main headings of "Softwoods" and "Hardwoods," particular timbers suitable for each building purpose are listed. Plywood, with notes on types of adhesives and species, is included in sections where it is considered suitable. The booklet is available without charge on application to the Timber Development Association, 21, College Hill, London, E.C.4.

Some Foreign Civil Engineering Schemes of 1953

No. 1

THIS review of foreign civil engineering projects which were in progress in 1953 starts with some examples of civil engineering on the American continent. In the United States, both the economic and technical "climates" encourage the construction of major projects of many kinds, which present a wealth of interest to the civil engineer. Two major schemes for the development of the water power resources of the United States, which were opened in 1953, are first described. The Hungry Horse dam and power station of the U.S. Bureau of Reclamation in North-Western Montana went into full operation in November, with power being produced by all four of the 71·25MW turbo-generator sets installed. Fig. 1 shows the completed dam and power station and the reservoir filled to a level of 3529·77ft above sea level, which is equivalent to a storage of 2,796,659 acre-feet. The dam is an arch-gravity structure with a height of 564ft.

The Pacific North-West power grid received the first electricity to be generated at the McNary scheme in the same month. The dam and lock of this scheme have been built on the Columbia River between the States of Oregon and Washington. This scheme was started in 1948 and is one of the major multiple-purpose reclamation projects of the U.S. Army Corps of Engineers. The power station will ultimately comprise fourteen 70MW turbo-generators which are scheduled for completion at intervals of about three months.

The McNary dam and lock is part of a comprehensive programme for the development of the Columbia River and its tributaries. The dam structures, containing 1,850,000 cubic yards of concrete and 2,100,000 cubic yards of earth fill, extend across the valley a distance of about 7600ft. The earth fill extends from the bank on the Washington shore a distance of 1560ft to join the concrete structure. The navigation lock, on the Washington shore, has clear dimensions of 86ft by 675ft and a minimum depth of 12ft over the mitre sills and covers the entire head of the scheme in a single lift. Guard walls, which are approximately 1400ft long, extending both upstream and downstream from the lock chamber, protect the river traffic from the spillway. An unconventional aspect of the lock design is the use of four sector gates in the filling and emptying culverts, with the concave faces of the gates on the pressure side. Model studies showed that far less turbulence was experienced during raising and lowering of the gates when they were placed in this manner. To provide access across the lock a double-leaf bascule bridge has been constructed. Immediately south of, and adjacent to, the lock is the non-overflow section of the dam through which the Washington shore fish ladder passes.

The spillway of the dam, which is shown in Fig. 2, extends to the south and consists of a concrete ogee section, controlled by twenty-two two-section, vertical-lift gates, 50ft wide and approximately 53ft high. The gates are operated by two 200-ton gantry cranes. A concrete stilling basin with baffles is provided downstream from the spillway. The lower sections of the gates, which are 24ft 6in high, normally remain seated on the crest of the ogee section, and the upper sections are then raised and lowered to regulate the pool level. With all gates removed the spillway is designed to pass 2,200,000 cusecs, or practically twice the maximum flood of record. Another non-overflow section of the dam, which is situated between the spillway and the power station, has an entrance to the Oregon shore fish ladder. This entrance is controlled by a closed flume along the downstream side of the power station. In addition, there is a collecting and passage channel extending the full length of the power station and having a total of eighty-seven entrance openings, forty-four of them equipped with automatically operated telescopic gates. There is also an entrance at the south end of the power station.

The power station, which is situated south of the spillway, will ultimately house fourteen 70MW generators, driven at 85·7 r.p.m. by Kaplan turbines, two station service generators and an assembly bay. The dam raises the natural water surface 85ft and creates a pool extending 64 miles upstream. At the dam site the Columbia River has a mean annual flow of 190,000 cusecs, varying from an extreme low of 33,000 cusecs to the high record of 1,210,000 cusecs, which occurred in 1894. To provide for the passage of the entire flow of the river and to keep interruptions in river navigation to a minimum, construction was divided into three major stages. The first-stage cofferdam, on the Washington side, above the low-water channels, included the navigation lock, the north non-overflow section, the Washington shore fish ladder, and thirteen and a half bays of the spillway. The second stage provided for a cofferdam on the Oregon shore

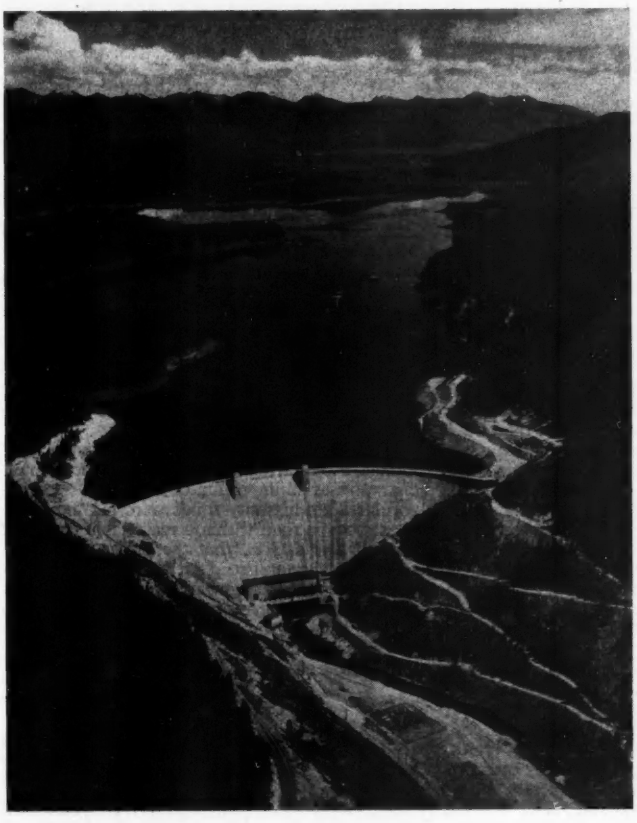


Fig. 1—Hungry Horse Dam, Power Station and Reservoir

adjacent to the main channel above low water, for construction of the south end of the power station substructure, comprising two main unit bays, station service and assembly bays, and the intake structure for that part of the station. The third and final stage included the construction of (1) twelve main unit bays of the power station substructure and intake structures for these bays; (2) the entire power station building; (3) the south non-overflow section of the dam; (4) eight and a half bays of the spillway within the main second-stage cofferdam, and raising the ogee section of the partially completed spillway bays; (5) completion of the upstream sill block of the navigation lock; (6) completion of the fish ladder on the Oregon shore; and (7) completion of embankments on both the Washington and Oregon shores. The pool was raised to its minimum operating level in the spring of 1953 on completion of the ogee crest of the spillway and the sill block of the navigation lock.

On December 15, 1953, the English Electric Company, Ltd., received a contract to supply the last two of the fourteen generators for the McNary project. Another British firm, Ferranti, Ltd., has received a contract to supply six large transformers for this scheme.

Much progress was made last year in the construction by the U.S. Army Corps of Engineers of the Garrison dam and reservoir on the Missouri River in North Dakota, which is to serve for flood control, power generation, irrigation, navigation and stream sanitation. At maximum normal operating level the Garrison reservoir will have a total capacity of 23,000,000 acre-feet, covering a length of 217 miles, a maximum width of 14 miles, and an area of 390,000 acres. It is believed that this will make it the largest man-made lake in the world. The dam is a rolled earth-fill structure, which will be 12,000ft long at the crest, with a maximum height of 210ft and a maximum base width of 2600ft. The crest width will be 60ft and the side slopes will range from 1 in 8 and 1 in 10 in the lower portions of the embankment to 1 in 2½ in the top portions. The ultimate total volume of the embankment will be 70,000,000 cubic yards, and nearly all the fill materials are to be obtained from the excavations for the spillway and the outlet works channels.

The embankment foundation consists of alluvial sand, extending as deep as 110ft on the east side of the river, and outwash clays with sand and gravel lenses on the west side. Underlying these materials and extending up to or near the surface on both sides of the river is the bedrock formation, which is highly consolidated and consists largely of clayey materials.

A system of outlet works has been provided in the west abutment of the dam for diversion of the river during the closure stage of dam construction and for the permanent control of water. The outlet works consist of eight tunnels through the dam, an intake structure with control gates at their upstream ends and a stilling basin and power plant at their downstream ends, with excavated channels leading to the river both upstream and downstream. The eight tunnels are nearly parallel in alignment, are about 1200ft long each, are all circular in cross section and have reinforced concrete linings. Five of the tunnels, each having a 29ft inside diameter, will serve as conduits for 24ft diameter steel penstocks leading to the turbines. The three most westerly tunnels will serve for reservoir regulation, discharging into a concrete stilling basin; two of these tunnels have an inside diameter of 22ft, and the third tunnel one of 26ft. Each of the three regulating tunnels is served by a single sector gate, 24ft 6in high by 18ft wide. Each of the five power tunnels is served by two vertical lift "caterpillar" gates, each 26ft high by 12ft wide, with a dividing pier between them. The concrete stilling basin is of the design conventionally employed for dissipating the energy of water flowing freely at high velocities from the end of a conduit. It is divided into three units to allow for operation of the three regulating tunnels individually or in any combination. Under maximum head and maximum flow conditions the height of the hydraulic jump in the stilling basin will be about 30ft. The overall dimensions of the structure as required to develop

Fig. 2—Spillway of McNary Dam Looking South from Washington Shore

and contain the hydraulic jump for all three tunnels are as follows : length, 470ft.; maximum height of walls above floor of stilling basin, 71ft.; and width of basin, 260ft.

The power station at the dam ultimately will consist of five 80MW turbo-generator units, three of which will be installed within the initial scheme of construction and the other two at a later date. Due to the length of the penstocks, two steel surge tanks, 65ft diameter by 135ft high, are being provided on each penstock at a point a short distance upstream from the power station. Provision is being made for complete enclosure of the surge tanks and the penstocks to obtain protection against excessive ice formation. The turbines are vertical-shaft Francis units, having runner diameters of 210½in, rated at 88,000 h.p., at or near maximum efficiency at a 150ft head. It is expected that the ultimate installation of five units will have a dependable capacity of 297·5MW, and an average annual gross energy output of 1,712,000,000kWh.

The spillway is situated high in the east abutment of the dam. Its design capacity is 827,000 cusecs at a reservoir level 16ft below the crest of the dam, and it is of concrete construction, with gate control at an ogee weir at the upstream end, where there will be twenty-eight sector gates, each 40ft long by 29ft high, individually operated by electric hoists mounted on the piers.

The Fort Patrick Henry dam, which for the time being will be the final hydro-electric scheme to be constructed by the Tennessee Valley Authority, approached completion during the past year, and its first 18MW turbo-generator was placed in commercial operation on December 5, 1953. The Authority is continuing to install additional generator sets at several of its power stations, and a third 67·5MW set is expected to commence operation at the Fontana dam shortly. It should perhaps be mentioned in this review that as a result of the recent change in Government in the United States, a new power policy has been adopted, and it is now certain that, in future, limitations will be imposed on the federal construction of multiple-purpose water power schemes.

Highway Engineering Works in the U.S.

The most important American highway scheme which was under construction during the past year is the New York State " Thruway." The road follows the scenic " water level route " from New York City to Buffalo and then continues to the Pennsylvania border along the shore of Lake Erie. Ultimately the highway will be more than 500 miles in length and will parallel or intersect most of the existing main highways of the state. Present construction work has been concentrated on the 427 mile long section which connects New York City with Buffalo and which passes near such important cities as Newburgh, Kingston, Albany, Schenectady, Utica, Syracuse and Rochester. It is expected that this section will be open to traffic in its entirety by the summer of 1955.

This motorway was planned originally as a limited access free highway with traffic " interchanges " at all important cross routes. Because regular State highway funds were insufficient to construct the road within a reasonable period of time, it was decided that the project should be self-supporting and paid for by tolls. This conversion from a free highway to a toll road brought with it many problems in the location and design of the " interchanges." On a free road the junction with a major highway, carrying a heavy volume of traffic, would be the conventional four-lobe clover leaf. For cross roads carrying lesser volumes of traffic, the conventional two-lobe clover leaf would be used. On a toll road it is necessary to bring all the turning movements at each junction into one " control area " at which tolls may be collected. The " interchange " between a toll road and a cross road carrying moderate volumes of traffic consists of a " trumpet " intersection and a connection with the local highways. For cross routes carrying heavy volumes of traffic a double trumpet is used. Because of high cost it was necessary to eliminate many of the " interchanges " originally scheduled. Altogether, there will now be thirty-five control and eighteen free " interchanges " and two control barriers between New York and Buffalo.

The entire highway will have no crossings " at grade " and no stop lights, and it has been designed to be suitable for travel at 70 m.p.h. Maximum gradients have been limited to 3 per cent, and horizontal curves to 2 deg., with a minimum radius of 2800ft. The concrete carriageway has a minimum thickness of 9in and is supported by a 4ft deep subgrade of selected, frost-free material. Opposing traffic lanes will be widely separated by a central reservation ranging from a minimum width of 20ft to several hundred feet. The minimum sight distances are 1000ft. The motorway provides two, and in some cases three, lanes in each direction. Two lanes, having a combined width of 25ft, are being constructed initially in most areas, but wherever additional capacity is needed three lanes totalling 37ft in width are being laid. The reservation is wide enough in all sections to allow the ultimate construction of a third lane on each side and still leave a broad dividing strip between vehicles moving in opposite directions. The outside shoulders will be 9ft or 10ft wide, depending upon the terrain, and will be stabilised to carry the weight of the heaviest vehicles, thus permitting parking in cases of emergency. An important safeguard is being provided at all " interchanges " and service areas. Extra right-hand lanes are being constructed at these points, in which entering vehicles may pick up speed before moving over to the traffic lane, and in which vehicles leaving may slow down before reaching the exit. It is believed that these acceleration and deceleration lanes, which are 12ft wide and 1200ft long, will minimise interference with through traffic and give added protection to drivers.

Altogether there are 525 places on the " Thruway " that require a bridge or viaduct, an average of one major structure for each mile. Most of the " grade separation " structures on the road are four-span beam bridges, one of which may be seen in the illustration Fig. 3, showing a completed section of the " Thruway " near Saugerties, New York. The piers supporting these structures are rounded columns, instead of the usual solid walls, providing good vision

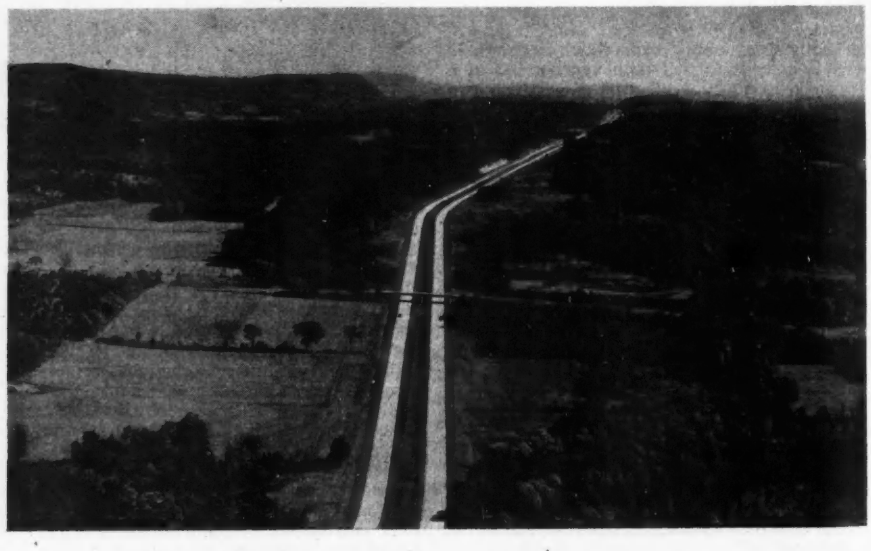


Fig. 3—New York State " Thruway " Near Saugerties

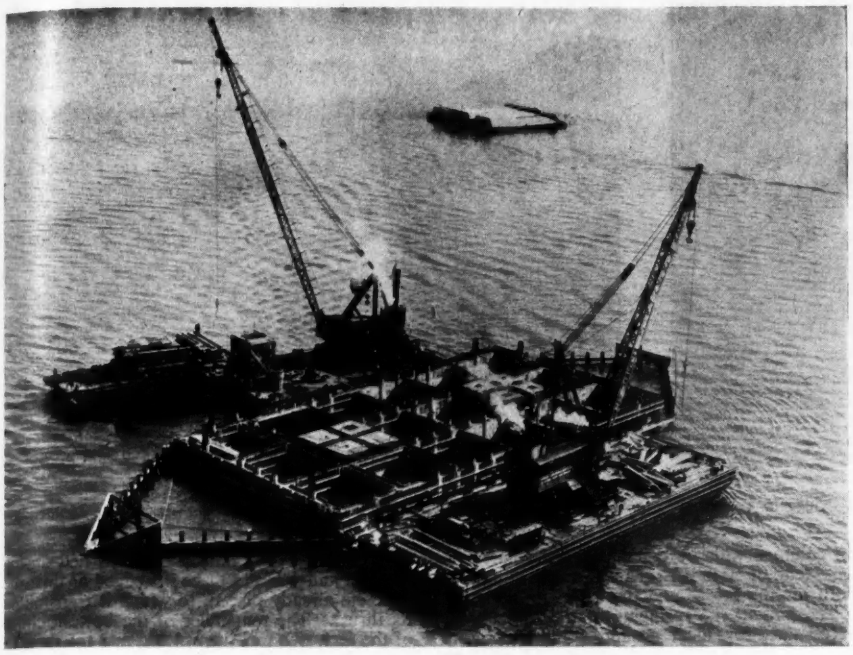


Fig. 4—Concrete Caisson for Hudson River Bridge

and substantially reducing the noise of a vehicle as it passes under the span.

Perhaps the most interesting highway bridge at present under construction in the United States is the six-lane structure which will carry the New York State "Thruway" across the Hudson River between Tarrytown and South Nyack, New York. Originally, the plans prepared by the consulting engineers called for a central 1112ft tied-arch span flanked by 400ft long deck trusses, but because of lack of interest in bidding on the superstructure, the main spans of the bridge had to be redesigned. The central arch and flanking truss spans have been replaced by cantilever trusses, which, in the opinion of the consulting engineers, will make this bridge one of the ugliest in America.

From shore to shore the bridge will be 15,300ft long. It will be about 92ft wide, allowing for three lanes of traffic in each direction, separated by a 10ft reservation, and two 3½ft wide walkways, which are provided for inspection and maintenance. At the west end, for a distance of 8000ft, there will be 160 steel stringer spans carried on concrete bents spaced 50ft apart. Continuing to the east, the roadway is carried on seven 250ft long deck trusses. In this part of the structure the transverse members also are trusses, rather than conventional solid-web girders. Next, to the east, are the cantilever trusses, which provide 135ft vertical clearance over the river channel. The centre portion spans 1212ft incorporating a 530ft suspended span, and the anchor arms, 600ft each. At the easterly end the bridge terminates in thirteen 238ft long deck truss spans.

The most unconventional aspects of the bridge design are the foundations and piers supporting the three cantilever spans and four deck trusses immediately to the west of them ; they comprise eight buoyant concrete caissons. This buoyant foundation design was specified by the consulting engineers because solid rock is too far below the silty river bottom—230ft to 300ft—to be used effectively and economically for pier support. The first of the caissons, which was floated downriver on October 12, 1953, was one of the two larger ones, being 190ft long by 100ft wide and almost 40ft high. Fig. 4 shows the caisson after arrival at the bridge site, where it was floated into position by manœuvring it into a fender system. All the eight caissons are to be built up to a uniform height of 40ft before being sunk into position and constructed a few feet short of that height in a natural dry dock at Grassy Point, New York, to ensure that they will ride sufficiently high to navigate the channel while being towed downriver. Once the remaining concrete has been added at the bridge site the boxes will be filled with water to sink them on a specially prepared 5ft blanket of sand and gravel 42ft below the surface. The coamings of an entrance hatchway in each box will protrude above the surface, permitting them to be pumped out as construction of the substructure progresses.

Open wells lined with corrugated galvanised iron run vertically through the walls of the caissons. After the caissons are sent to the bottom 30in diameter steel pipe piles up to 270ft long will be driven to bed rock through these wells in the larger boxes. After being driven the pipe piles will be cleaned out, filled with concrete and then be encased by concrete within the walls, to pin the caissons in place permanently. As the erection of the superstructure will add deadweight, the water will be pumped from the boxes to obtain the desired buoyancy. It is estimated that their buoyancy will support 80 per cent of the overhead dead load of the bridge, with the piles supporting the balance, as well as all of the live load. The eight caissons vary appreciably in size, but otherwise are similar in construction. The two for the main pier are 190ft long by 100ft wide, the two for the flanking piers are 124ft 6in by 77ft, and the four smaller ones are 110ft by 56ft. Their base slabs are approximately 2ft 4in thick and their exterior walls are 3ft 9in thick, widening to 4ft 8in at the point where they are pierced vertically by the wells through which the piles are to be driven. The hollow interiors are divided into reinforced compartments, with an intermediate slab running the length of each box. Weep holes connect the compartments and there is a sump in each caisson for pumping out any seepage. The two largest caissons are divided into twenty-four compartments, the two medium-sized ones into twelve compartments and the four smallest ones into eight.

The pit in which the eight large caissons were built was fashioned from a worked-out clay pit on the bank of the Hudson River, 10 miles north of the bridge site, which, through the years, had filled with water to form a lake almost half a mile long, 600ft wide and up to 42ft deep. The pit was pumped dry and construction of the caissons was started in January, 1953 and completed in October.

Contracts were awarded in 1953 for the construction of a suspension bridge across the Straits of Mackinac, connecting the upper and lower peninsulas of the State of Michigan. The structure includes 9304ft of truss spans and a suspension bridge which is 8614ft in length from anchorage to anchorage. The main span of the suspension bridge will be 3800ft long and will thus be second only in length to the Golden Gate bridge in San Francisco. Designed for a live load of 2000 lb per lineal foot, the bridge will carry two lanes of traffic in each direction, separated by a low 2ft wide "mall." The roadway will be 48ft wide between kerbs, and footways 3ft wide along both sides will bring the total width between railings to 54ft. The roadway will have a maximum gradient of 2·5 per cent to provide a minimum clear height above a mean lake level of 135ft for a width of 3000ft over the main channel. The bridge span will be suspended from two 24·25in diameter cables situated at a centre distance of 68ft and comprising thirty-seven individual strands. Each strand will be composed of 348 galvanised 0·196in diameter wires. The cable sag will be 350ft, equivalent to about one-eleventh of the centre span. The bridge towers will rise to a height of 552ft above lake level. The construction schedule, as established by the consulting engineers, calls for the bridge to be open to traffic by the end of 1956.

Some Highway Works in Central and South America

We illustrate in Fig. 5 a novel bridge erected over the Blanco River, near Vera Cruz, in Mexico, and opened last May. The bridge is of all-welded steel design, with a span of 250ft, and is based on the winning design, by Dr. T. C. Kavanagh, of New York University, of the 1951 competition organised by the Lincoln Arc Welding Foundation for a welded highway bridge. The bridge accommodates three lanes of traffic, and the originality of its design will be apparent from the illustration. One refinement not shown in the illustration may be mentioned, however : the floor beams are placed diagonally

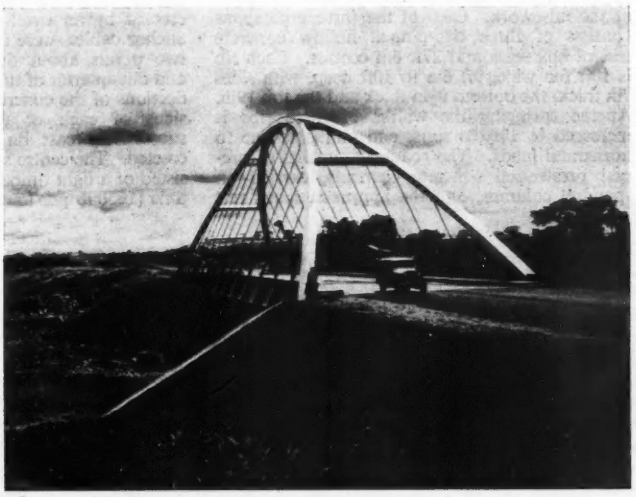


Fig. 5—Welded Highway Bridge Spanning River Blanco, Mexico

to form structurally a highly redundant grid, which, although complicated in analysis, permits an appreciable economy of materials. The novelty of the bridge has been enhanced by its colouring ; the arched ribs have been painted orange and the tie girders cherry red.

Further south, in Venezuela, an important motorway which connects the capital Caracas with the sea and airports at La Guaira, was completed in 1953, being inaugurated on December 3rd, by the President of Venezuela. The motorway is nearly 11 miles long, superseding a 19-mile route, and it crosses some extremely awkward country of steep slopes and gorges, subject to landslides after heavy rain. Work was started on

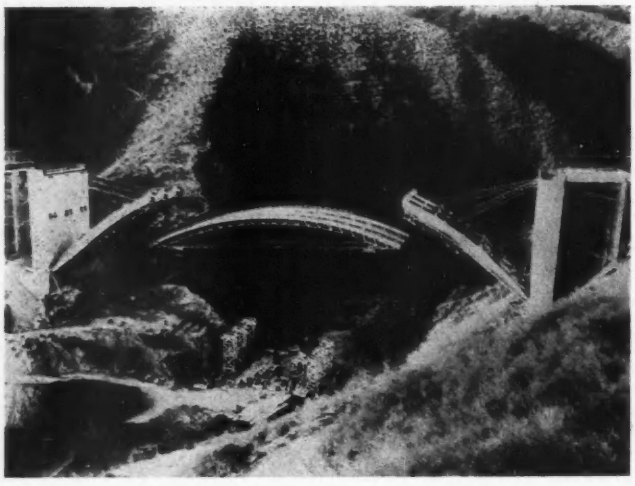


Fig. 6—Erection of Central Formwork Unit of Arched Bridge in Venezuela

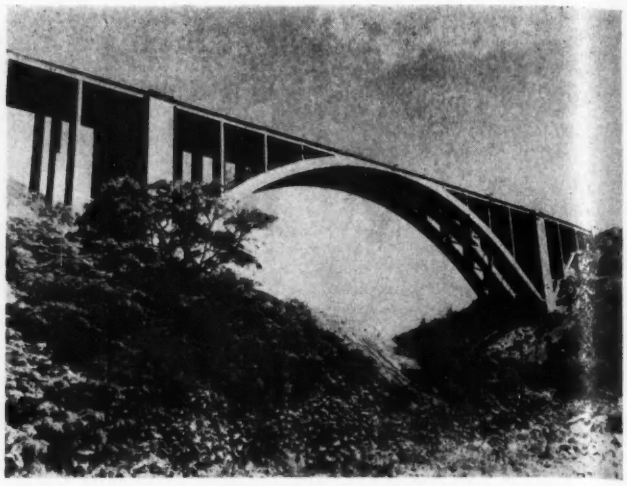


Fig. 7—498ft Span Concrete Arched Bridge on Cavacas—La Guaira Motorway

the new motorway in 1950: it consists of two 24ft carriageways with a central reservation 4ft or 5ft wide and with paved " shoulders " on each side. Apart from heavy earth-moving work, two double tunnels, respectively about 6000ft and 1500ft in length (the dual 24ft carriageways are each accommodated in a separate tunnel), were driven, and three major bridges have been erected. The tunnels were begun in 1951, and the first of the three bridges was virtually complete at the beginning of the year, although a substantial volume of work on the other two was carried out during 1953. The motorway cost approximately £25,000,000 to construct, and it is being used as a toll highway, so that the cost may be recovered.

The three bridges are basically similar in conception and execution, having main arch spans of 498ft, 478ft and 453ft respectively. They were designed by Monsieur Freyssinet and erected by Entreprises Campenon Bernard. A similarity between these arches and the Plougastel bridge in France is apparent, but the conditions at the sites of the Venezuelan bridges were rather different, and necessitated an original approach, particularly in the design and erection of the falsework. Each of the three arch spans consists of three two-pinned hollow concrete ribs of box section at 27ft 6in centres. Each rib is 10ft 6in wide, 9ft 6in to 10ft deep, with sides 7in thick, the bottom 9½in thick and the top 19in. At the springing the widths of these ribs is increased to 17ft to resist end moments due to horizontal loads. The roadway consists of precast prestressed concrete elements, carried on spandrel columns, and the approach spans rest on columns which are hinged at the base. A wind load of 50 lb per square foot was stipulated both for the bridge and the centering design.

The pins at the springing of the arches were necessitated by local ground conditions. For the first bridge a hollow prestressed concrete box structure was built into the slope to form one of the arch foundations, thus distributing the bearing load of 16,000 tons at a pressure of 3·5 tons per square foot. For the other abutment vertical footing was carried down to bedrock, and an inclined heading was driven for each of the arch ribs to a depth of nearly 100ft and concreted to give a sound bearing on to solid rock to take the side thrust. The soffit of the arch is 220ft above the valley bottom at the centre of the span.

Owing to the steepness and treacherous nature of the site and to the possibility of high winds, the centering for the main arch ribs presented one of the most difficult problems of the entire work. An unconventional solution was adopted, involving a complicated erection schedule in various stages, one of which is illustrated in Fig. 6. Two cantilever sections of falsework, erected by an overhead cableway and held by anchor cables, were first erected in stages out to two points about three-quarters of the height and one-quarter of the span from each abutment. Sections of the concrete forming the bottom and sides of each of the box-shaped ribs were successively cast on this centering, as it was erected. The centre section of the centering consisted of a light timber trussed arch weighing 220 tons (1650 lb per lineal-foot), which was hoisted into position. The timber arch was tied during erection and when in place it wedged against the concrete already placed, to which it transmitted its thrust. The remainder of the bottom chord of the arch ribs was then placed and the remaining part of the sides and the tops of the ribs were subsequently cast in separate stages, supported on the combined centering and bottom chord. This method of construction explains why the hollow ribs were given a greater thickness at the top than at the bottom.

The falsework units, and also the shuttering for the deck beams, which was extendable for casting different lengths of beam, were used for the construction of all three of the bridges. The first bridge is shown in Fig. 7, and the launching of a deck beam on the approach spans is shown in Fig. 8 ; the temporary steel bracing, necessitated by the pinned feet of the columns, may be noted in the latter illustration.

(To be continued)

Fig. 8—Erection of Precast Prestressed Deck Beams on Approach Spans of Arched Bridge

" Production for Plenty " Exhibition and Conference

Some further notes have been issued on the " Production for Plenty " exhibition and conference sponsored by the Institution of Production Engineers which it is proposed to hold at Olympia from July 7th to 14th next. The exhibition is intended to show the many factors contributing to improvement of productivity in British industry, and how better production methods and increased output make available better and cheaper goods to raise the standard of living.

The Department of Scientific and Industrial Research and the British Standards Institution have stated their intention to participate in the exhibition and conference, whilst the British Productivity Council and other organisations propose to contribute to the conference. It is stated that the exhibition will offer facilities to research and trade associations, industrial groups and perhaps some individual manufacturers to demonstrate how their industries are contributing to a higher standard of living. The exhibition will be divided into a number of sections including research and development, education and training, management and employees, processes, planning and work study, welfare and safety, materials, plant and equipment, services and aids, and finished products.

The conference will be opened by the Earl of Halsbury, who will present the 1954 Sir Alfred Herbert Lecture of the Institution of Production Engineers. Papers are to be read and discussed dealing with the relationship between research and production in a number of industrial fields.

" Handbook of the Fan Engineering Industry."—The Fan Manufacturers Association, Ltd., 59–62, High Holborn, London, W.C.1, has just issued a " Handbook of the Fan Engineering Industry." This book gives particulars of the Association, its aims and objects, notes on fan design and types, and a range of fan applications in heating and ventilating.

Gas Turbines in 1953

No. II—(*Concluded from page 89, January 15th*)

JOHN BROWN AND CO. (CLYDEBANK), LTD.

APART from the brief references made in last week's issue to two of the projects in hand by John Brown and Co. (Clydebank), Ltd., we learn that it has now completed 455 hours' running on its small experimental closed cycle set installed in the works, using a pulverised coal fuel of a quality similar to that normally supplied to power stations. The results were stated to be so satisfactory that the set has now been modified to burn coal slurries.

PAMETRADA

Details of marine gas turbine research being carried out by Pametrada were published in THE ENGINEER, October 16th, on the occasion of a visit to the establishment at that time. In 1952 the 3500 s.h.p. gas turbine had satisfactorily completed a continuous run of 100 hours at full power and was completely opened up and inspected by Lloyd's. One of the problems Pametrada has since been working on in connection with this set has been the distortion of the high-pressure and low-pressure cylinders due to the higher temperatures involved with the gas turbine cycle. Part of the low-pressure cylinder is shown below. The problems of this set were largely overcome by modifying the flanges and altering the method of support of the cylinders. The behaviour of the casings, however, was still not satisfactory under rapidly changing temperature conditions, and a new method of supporting the casing was developed, which was stated should overcome the remaining distortion problems. These modifications are designed to reduce turbine casing distortion and differential expansion between turbine rotors and cylinders during the running-up period, and should enable full power to be obtained from the " engines stopped " condition in under one hour. They make the maximum use of existing components, namely, rotors, cylinders and blading.

The casing design follows the latest Pametrada steam turbine practice, the rotor and cylinder being supported by a fabricated outer casing which allows free thermal expansion of the components while maintaining alignment of the rotor, cylinder and glands. The rotor modifications incorporate blade fixing which enables the thermal inertia of the rotor to be reduced by " gashing " between the closely spaced blade rows of the existing rotor. The cylinder blades are provided with diaphragms freely supported in channel section shrouds attached by pins to the blades.

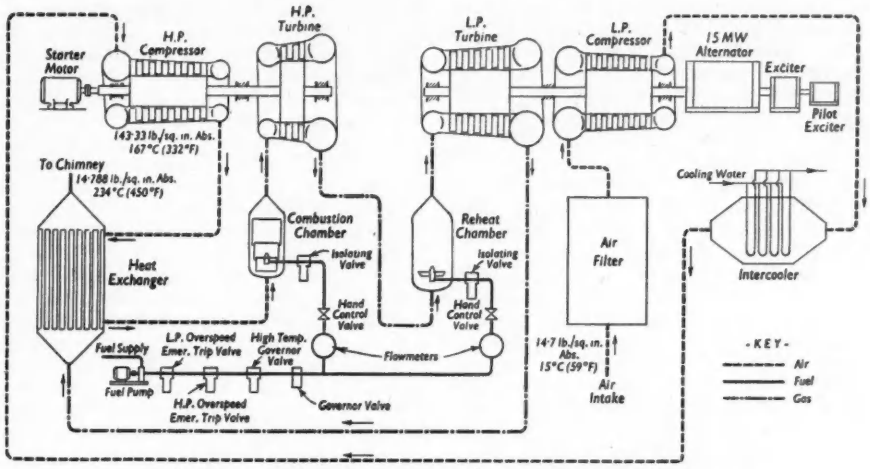
This installation is not to go to sea as the establishment regards it as far too valuable a research tool. Furthermore, it was stated that since its design in 1946 so much has been learned from development work that the existing unit is already out of date.

Liquid Cooling of Gas Turbine Rotor Blades.—An apparatus has been designed by Pametrada, under Admiralty contract, to investigate the liquid cooling of gas turbine rotor blades. The method used is well known, making use of the powerful convection currents which occur in the centrifugal field of force produced by rotation. While turbines using this system have actually been made, little detailed information is available and it is the purpose of these experiments to supply it.

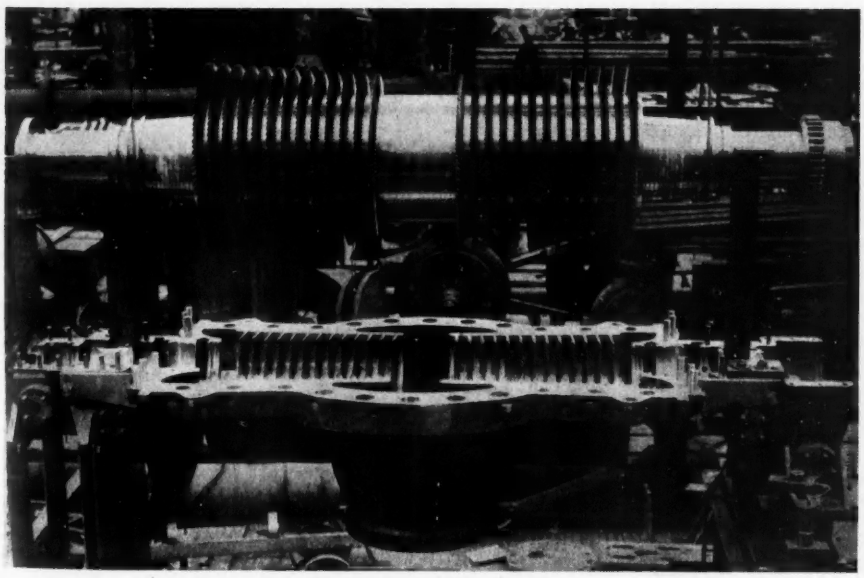
The blades are represented by two circular tubes carried at the ends of rotating arms. With suitable liquids enclosed in the tubes, heat is supplied electrically to the outer sections of the tubes and taken away by water flowing over the roots, while measurements are made of tube temperatures and heat flow rates.

The fixed blades cannot be cooled by the same method, but are less highly stressed. Since the temperature in view is 2200 deg. Fah., which is much higher than any form of steel could withstand, it is proposed to make the fixed blades of refractory materials. Refractories fully capable of withstanding such temperatures are available, the limiting factor in this case being ability to withstand thermal shock. Pametrada has therefore been submitting refractory materials to severe thermal shocks and observing their resistance.

The Association is actively engaged in the manufacture of an experimental single-stage turbine with refractory fixed blades and liquid-cooled moving blades. The results of previous tests indicate that the difficulties associated with the refractory materials can be satisfactorily overcome.



Cycle Diagram of 15MW Gas Turbine Set at Trafford Park, Manchester



L.P. Cylinder of Pametrada 3500 h.p. Marine Gas Turbine

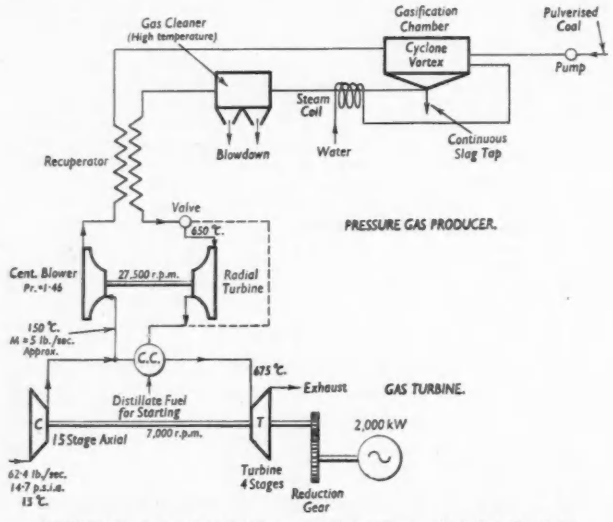
METROPOLITAN-VICKERS ELECTRICAL COMPANY, LTD.

A considerable amount of running experience has been gained during the year on the 15MW gas turbine generating set, which was put on load at the Trafford Park power station on August 6, 1952. Due to the proximity of this power station to the works of Metropolitan-Vickers, the installation was not bench tested at the works and consequently its early running has been largely of a development nature. No details of this experience are as yet available. The set was fully described in THE ENGINEER, September 12, 1952, from where the cycle diagram above is reproduced. It is a two-shaft installation with an overall compression ratio of 10 : 1 and employing intercooling, heat exchange and reheat units. The gas admission temperature to both the high-pressure and low-pressure turbines is 1200 deg. Fah., and the design overall efficiency was estimated at 28 per cent. Gas oil was initially used, after which it was intended to modify the plant to use heavier grade oils. The speed of the low-pressure shaft, which is directly coupled to the 15MW generator, is maintained constant

at 3000 r.p.m., whilst that of the high-pressure shaft has a maximum value of 5500 r.p.m. at full load.

The 1750kW set for Shell Petroleum, designed to burn natural gas in the Venezuelan oilfields, has been tested on refinery gas at Pernis Refinery in Holland. The official acceptance tests culminated in a fourteen-day continuous load test. Since completion of the official tests the Shell Company has carried out further running at Pernis Refinery, bringing the running time up to a total of 2000 hours. The turbine component was returned to the works for inspection on completion of this running and was found to be in excellent condition. This generating set is a simple single-shaft unit, the overall design efficiency being given as 15 per cent. The design conditions of the cycle indicate a mass flow of 54·5 lb per second, a pressure ratio over fifteen axial stages of 5·2 : 1, a shaft speed of 7000 r.p.m., and a turbine inlet temperature of 640 deg. Cent. The alternator is driven through reduction gearing.

The 2500kW standby set for the Metropolitan Water Board completed its bench testing at works during the year and has been delivered to site.



2000kW Producer Gas Set Incorporating a Pressurised Gas Producer

This set was designed to run on light oil with an overall efficiency of 16·5 per cent. The design particulars indicate a fifteen-stage compressor, mass flow 60 lb per second and pressure ratio 5·38 : 1, a four-stage turbine with an inlet temperature of 700 deg. Cent. and a shaft speed of 7000 r.p.m.

The company's experimental gas turbine plant, in addition to carrying the factory peak loads, has been run experimentally on various batches of heavy oil fuel. The cycle employs a free power turbine and heat exchange.

Extensive sea trials of the two naval motor torpedo boats, "Bold Pioneer" and "Bold Pathfinder," were carried out during the year. Each boat is equipped with two "G.2" gas turbines rated at 4500 s.h.p. each and with two diesel engines for cruising. This engine, which was fully described in THE ENGINEER, January 9, 1953, is largely based on the company's original "Beryl" aeronautical turbo jet engine with the addition of a free power turbine. The specific weight of the unit, including the reduction gearing, is 2·16 lb per s.h.p. It has a life of 1000 hours, of which 300 hours may be at maximum load. Gas temperature at the turbine inlet is 806 deg. Cent., and the maximum compressor speed is 7830 r.p.m.

No further details concerning the 2000kW set incorporating a pressure gas producer were released during the year. It was briefly described in our review last year, and on this page is shown the complete cycle diagram.

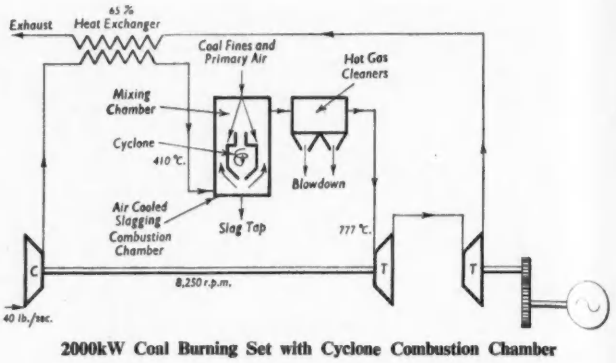
ENGLISH ELECTRIC COMPANY, LTD.

No information concerning the 20MW installation which the English Electric Company, Ltd., is developing was released last year, although some reports suggest it has two stage compression and a free power turbine.

Details of the 6500 h.p. naval gas turbine, on which the company completed extensive shore trials, were given in THE ENGINEER, Feb. 13, 1953. It was designed to investigate the behaviour of a marine gas turbine built on steam turbine principles as distinct from the kinematic construction associated with aeronautical and certain industrial installations. In this particular case serious difficulties arising with the higher temperatures involved were experienced with the turbine cylinders during its early running, and the application of this set to H.M.S. "Hotham," a naval frigate, is not now being proceeded with.

The parallel cycle employed had a single axial compressor of fifteen stages, the pressure rate being 4·1 at a speed of 4000 r.p.m. and the mass flow 128 lb per second. About two-thirds of this flow passes through a heat exchanger and four combustion chambers to a five-stage turbine mounted on the compressor shaft. The inlet temperature is 700 deg. Cent. and the charging turbine develops 13,700 h.p. The gases exhausted via the heat exchanger to atmosphere. The remainder of the flow passed via throttle and blow-off valves through another heat exchanger and two combustion chambers to a free turbine of five stages, admission temperature 700 deg. Cent. also, running at the alternator speed of 5600 r.p.m.

The cycle diagrams for two other installations the company is engaged upon are reproduced herewith, but no further information concerning progress or experience with these units is available. One of these sets for the Ministry of Supply was designed to burn coal using a cyclone "slagging" chamber. In this form of combustion chamber combustion largely takes place on the walls, down which most of the ash can be collected in a molten state. The ash which remains in suspension is then attended to in hot gas cleaners placed before the turbines.

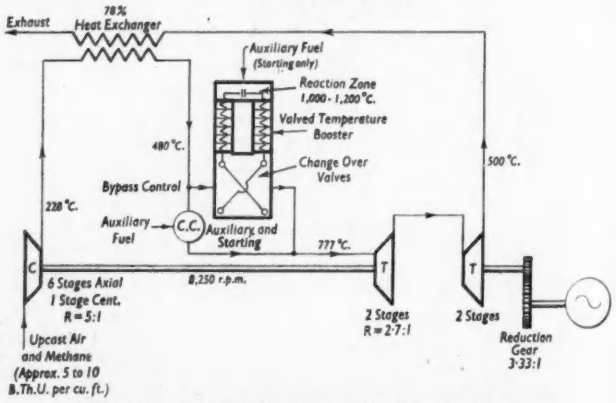


2000kW Coal Burning Set with Cyclone Combustion Chamber

The British Coal Utilisation Research Association has been responsible, as mentioned earlier in No. I, for the development of this chamber. The heat exchanger of this cycle is also of interest, and some details of it have been published.* After experimentation concludes with this installation it will be used as an industrial plant.

The lower diagram represents the cycle of an installation primarily designed to burn the exceptionally weak mixture of pit upcast air and methane (about 1 per cent), the basic mechanical details of both these sets being similar. The heating element consists essentially of a regenerative heat exchanger having two legs, each composed of elements of a ceramic matrix, their orientation alternating. These columns are bridged by a high-temperature reaction chamber. If fire-damp is preheated to about 1000 deg. Cent. a reaction takes place, in which complete oxidisation occurs and a further though slight increase in temperature takes place of about 200 deg. Cent. The fire-damp, after compression, passes up one leg, across the reaction bridge and down the other, the direction being cyclically reversed. At an instant before a reversal of flow takes place the gases, after oxidisation is complete, pass down one leg of the regenerator to the turbine, so raising the temperature of every element. After reversal fire-damp passes up this leg, which is now capable of progressively heating the fluid up to its oxidisation temperature just prior to its admission to the reaction bridge. There its temperature is raised a further 200 deg. Cent. (approximately) and in passing down the other leg restores the heat which was lost following its functioning as a hot source in the previous cycle. The gases leave the

* The Institution of Mechanical Engineers, "Some Fuel and Power Prospects," H. Roxbee Cox, November 16, 1951. See THE ENGINEER, November 23, 1951.



2000kW Firedamp Set with Regenerative Heat Exchanger as Combustor

regenerator at about 780 deg. Cent. and the system by virtue of the temperature "head" developed in the bridging chamber, in conjunction with cyclic reversal of the flow, is thereby a continuous one. The cycle illustrated incorporates a conventional combustion chamber also, which it is eventually envisaged will burn coal dust with fire-damp as the primary combustion air. The combined cycle would thus be capable of usefully consuming two waste products of a coal mine. The installation of this plant at a coal mine was scheduled to take place early last year. Basic research on this treatment of fire-damp was directed by Sir Alfred Egerton at the Imperial College, and Mr. R. G. Voysey proposed the use of the regenerator.

British Thomson-Houston Company, Ltd.

One of two gas turbines made for the East African Power and Lighting Company, Ltd., was delivered to the Nairobi South power station last year. It had satisfactorily concluded 550 hours' test running with and without load and had operated for 200 hours at full load on a residual fuel oil of viscosity 500 seconds Redwood at 100 deg. Fah. Both sets are of 2500kW capacity. No other details of these sets are available, but an early design specification showed the use of four centrifugal compressors in series on a single shaft driving the turbines at 3500 r.p.m. The cycle included a heat exchanger.

In February last year it was announced that the Anglo-Saxon Petroleum Company, Ltd., had ordered an 18,000-ton tanker, which was to be driven solely by gas turbines. These gas turbines have been designed by British Thomson-Houston Company, Ltd., but some of the components are to be made by Cammell Laird and Co., Ltd., which is building the ship for delivery in 1956.

The machinery will comprise two gas turbo-alternator units driving the single propeller shaft through two electric motors and a two-pinion single reduction gearbox. Power for all auxiliary requirements at sea and in port will be drawn from the propulsion gas turbines, including that required for the 2000 tons per hour cargo pumps. A diesel alternator will be provided to supply power for ship's services when the gas turbine alternators are not in use.

Each unit, which was originally stated to be of 4150 h.p. capacity, will have two-stage compression with intercooling. The high-pressure line will comprise turbine and compressor; the low-pressure line will comprise turbine, compressor and propulsion alternator. The installations operate on an open cycle. Steam for cargo heating and tank cleaning will be obtained from a small oil-fired boiler in conjunction with waste heat boilers taking exhaust gas from the heat exchangers of the turbine.

The propeller motors will be of the double-cage induction design. Astern running will be obtained by reversing contactors in the main electric circuit, and consequently with no change in the turbine direction of rotation and with full power available for astern running. Between 100 r.p.m. and approximately 55 r.p.m. the speed of the propeller will be controlled at the turbine. Lower propeller speeds will be obtained by reducing the voltage applied to the propeller induction motors, the controls being in the alternator exciter circuits. The four centrifugal cargo pumps and one of the two stripping pumps will be electrically driven at 3000V from the propulsion alternator. The other stripping pump is of the steam reciprocating type.

With the experience the company has gained with the "Auris" set the justification for intercooling because of the increased mass flow and the relative freedom from space restrictions on the cycle layout and component design, it is hoped to achieve a thermal efficiency not less than 27 per cent and a fuel consumption of the order of 0·53 lb per brake horsepower per hour and to operate exclusively on normal grades of boiler fuel.

There were two papers read on the company's 1200 b.h.p. open cycle set, which was installed in the tanker "Auris," and has been in operation at sea since October, 1951. By arrangement between the authors both papers were complementary. The paper "The Marine Gas Turbine," by B. E. G. Forsling, read before the Institution of Mechanical Engineers on November 27th and abstracted in The Engineer, December 4th, discussed the background and the theoretical considerations associated with the set, whilst the other, by J. Lamb and R. M. Duggan, was confined to the aspects suggested by its title, "Operation of a Marine Gas Turbine Under Sea Conditions," read before the Institute of Marine Engineers on October 13th. In two years' operation at sea and including its initial running on the test bed a total of 11,200 hours' operation on load had been logged. It regularly achieved a fuel consumption of 0·75 lb per horsepower per hour. A certain amount of corrosion and oxidisation were experienced on the stator and the hotter turbine stages, and the temperature was reduced from 1200 deg. to 1100 deg. Fah. This was due in part to gas temperature stratification, which factor was simply corrected. It was pointed out by the authors also that the set, including its blades, was eight years old and that with blade materials now available, such as Nimonic 80A blades which are now being fitted to the set, a blade life not less than 20,000 hours should be possible under the same conditions.

The Blackburn and General Aircraft, Ltd.

In October, 1952, the Blackburn and General Aircraft, Ltd., acquired the exclusive manufacturing and selling rights of the Turbomeca range of gas turbines in the United Kingdom and the selling rights in the British Commonwealth. The range extends from 158 to 394 horsepower units, the basic design concept being retained in all engines. This includes single-stage centrifugal compression, a very compact annular combustion chamber and single or multi-stage turbines. The shaft drive is either an extension of the compressor turbine shafting or is separate from it and driven by a free turbine. The annular combustion chamber, with rotating disc fuel distributor and burner, is an important development which allows the engine to be very compact. The maximum continuous fuel consumption for all the units, except one, lies between 1·02 lb and 1·2 lb per horsepower per hour, the lightest having a specific weight of 0·5 lb per horsepower. The Turbomeca range of gas turbines has been developed in France under the direction of Monsieur J. Szydlowski. A great deal of progress has been achieved in the past fourteen years. These units have been used successfully to solve various industrial and aeronautical problems, the full range of engines covering such applications as air compression, jet propulsion and the provision of shaft power.

Opening of the Queen Elizabeth II Oil Dock at Eastham

A large oil dock at Eastham capable of handling the largest tankers was opened last Tuesday and named the Queen Elizabeth II Dock. The dock has been under construction since 1949 *and serves refineries in the Stanlow area. It was built by the Manchester Ship Canal Company at a cost of* £5,750,000, *and is situated next to the entrance of the ship canal.*

THE new oil dock at Eastham, next to the entrance of the Manchester Ship Canal, was opened last Tuesday, January 19th. Its inauguration was accompanied by much pageantry and ceremony, as befits the successful completion of a vast and intricate engineering project.

The oil dock will accommodate the largest modern tankers. Its basic layout is simple, consisting of an entrance lock from the River Mersey, leading into the oil dock itself, which is approximately square, with four berths of 800ft, 725ft, 900ft and 730ft in length. In the general view of the dock shown in the first of the illustrations with this article, the entrance lock can be seen at the far corner of the dock. In the background a ship may be seen in the Manchester Ship Canal, which runs close to one side of the dock. The entrance lock into the River Mersey is shown in the second illustration; the lock is 807ft long and 100ft wide, and is controlled by three caisson gates. A comprehensive description of the civil engineering works for the new dock was published in The Engineer just over a year ago in our issues of December 19 and 26, 1952. But some of the principal points in its design and construction will again be given here, in a brief overall account.

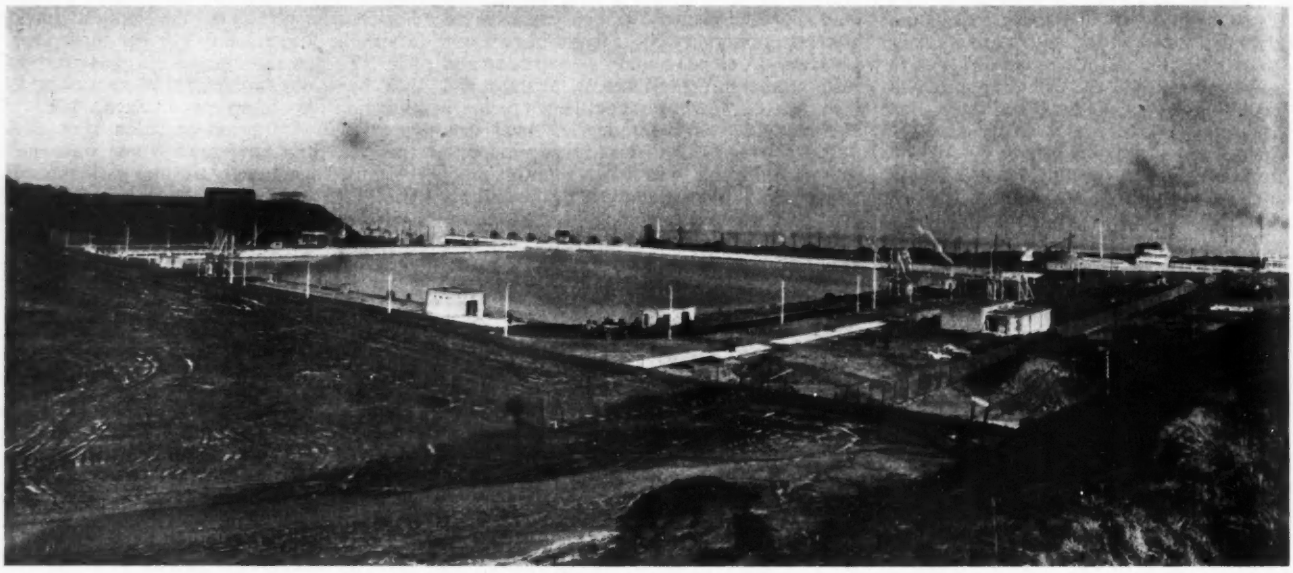
One of the most remarkable developments in post-war trade has been the change, owing to the dollar problem, to a policy of refining in this country which has increased British refinery capacity almost sevenfold. As a result, oil imports have increased greatly and, in particular, great developments in refinery facilities have taken place along the length of the Manchester Ship Canal not only at Stanlow but at Partington (Petro chemicals, Ltd.) and Manchester itself.

The Port of Manchester is in the centre of a highly industrialised area with a population which challenges comparison with that of London and its hinterland. Within 75 miles of the City of Manchester there is a population of no less than 14,500,000 people—half a million more than the population of a similar radius of London. This is one of the reasons which has led to the development of the Stanlow area, for here there are concentrated not only the means of inland distribution by water, rail and road, but also facilities for coastwise distribution and export shipment. Thirty years ago the Stanlow area consisted of agricultural grazing land. In 1922 an oil dock was built in the Stanlow peninsula and made available for the handling of low flash petroleum products. This was followed eleven years later by a second oil dock. From then onwards an impressive proportion of the country's imports of petroleum spirit was centred upon the Port of Manchester, and upon Stanlow oil docks in particular, where there is now established a concentration of oil refineries and oil tank installations, of the Esso Petroleum Company, Ltd., Cleveland Petroleum Company, Ltd., National Benzole Company, Ltd., Berry Wiggins and Co., Ltd., C. C. Wakefield and Co., Ltd., Cabot Carbon and Co., Ltd., Associated Ethyl Co., Ltd., and Lobitos Oilfields, Ltd. The largest refinery of all, at the present time, is that built by the Shell Refining and Marketing Co., Ltd., which, with its allied interests, occupies an area of 1700 acres. The Shell Company claims that this refinery is the most comprehensive integrated

refinery in the world, outside the United States. It was in order to cater for the petroleum industry and not least for this great new refinery that the oil dock was built. It accommodates tankers which are too large in size for the ship canal and it and the refinery are closely connected by the Shell Refining and Marketing Company's pipelines, designed both for the import of crude oil and the shipment of refined products.

The dock has a water area of 19 acres. It has been excavated principally out of sandstone formations, and it has mass concrete quay walls, the bottom of the dock being left as excavated. It is connected by culverts to the ship canal, and thus maintains the same level as the canal, which is replenished at high tides and is not maintained by pumping. The depth of water in the dock is about 40ft, the sill of the entrance lock being at 20ft below Liverpool Bay Datum. There is a dredged channel in the Mersey approaching the entrance lock, 500ft wide and dredged to 15ft below Bay Datum, which gives a depth of about 44ft at H.W.O.S.T.

The project involved the excavation of about 3,250,000 cubic yards of spoil, mainly soft sandstone, and the emplacement of nearly half a million cubic yards of concrete in the gravity walls of the dock and entrance lock. The method of handling the spoil was considered to be an innovation for this class of work. Conveyor belts, with hoppers to receive excavated material from the draglines, and with throw-off carriages for spreading muck on the tips, were installed from the dock to the deposit grounds, to handle all the excavation. Conveyor belts were also used for concreting; they travelled at 280ft a minute, so that concrete could reach the farthest point of the dock from the batching plant in about twelve minutes. A rate of concreting of about 2750 cubic yards a week was maintained. Fuller details of the conveyor installation, and also of the steel caisson gates with their interesting control gear (which allows infinitely variable speed regulation from zero to full speed, with automatic speed regulation to suit the load, when a caisson is being opened or closed) were given in our earlier article. Other interesting points in the civil engineering work included the use of a massive gravity cofferdam enclosing the lock and its entrance wall, and the employment of a novel climbing shutter for the concrete work. The deposit grounds have been graded to fit into the landscape, and top soil placed over them; they are now in agricultural use.



The Queen Elizabeth II Oil Dock at Eastham

Model Experiments

A great deal of experimental work was carried out at Manchester University on large-scale models of both the lock and the dock. Amongst the problems investigated was the behaviour of the larger type of tanker as it entered a lock, and the determination of the best speed of approach for deeply laden vessels. The turbulence which is always caused in locks while the sluices are in operation was also examined on the model, and the information obtained from this research enabled the sluice openings to be designed to produce a minimum of turbulence. It also indicated how the spacing of the sluice openings could be arranged to give a uniform distribution of silt on the floor of the lock. The effect will be to reduce the dredging required to maintain a navigable depth.

During December, 1951, a scale model of the new lock was erected inside the 3ft 6in wide flume at Manchester University. The model lock, which was built of timber and hard board, was originally designed to a scale of 1in to 11ft, or 1 : 132. A model tanker, constructed to the same scale as the lock, was guided by two brass forks, which slid along overhead rails of drawn steel. By adjusting the position of the rails it was possible to start the boat on any chosen course. The rails and forks were arranged so that the ship left both guide rails simultaneously. The movements of the vessel before and after leaving the rails were plotted by four glass pens, two at the bows and two at the stern, which traced on to squared paper placed on boards on each side of the lock, giving a complete record of the motion of the vessel. A very light form of construction was used for the pens, which could move freely about a horizontal axis.

With the initial scale of 1 : 132 the beam of the model tanker corresponded to 88ft. A hook and string supported by a system of pulleys were used to haul the boat along. Use was made of a governed clockwork motor to provide a constant-speed drive for the towing assembly. It was found that the forward pull of the hook did not in any way prevent the bow of the vessel from sheering to either port or starboard.

During the experiments the boat was loaded to correspond to draughts of 28ft, 33ft and 37ft, whilst the depth of water was adjusted to 40ft, 43ft or 54ft. With various combinations of these settings and utilising a range of speeds, the motion of the ship was recorded as it approached and entered the lock. For these tests the vessel left the guide rails at 230ft outside the bullnose at the entrance to the lock. The guide rails were originally arranged in one of two positions: (*a*) to steer the vessel on a central path, (*b*) with approximately 1·5ft clearance between the starboard side of the ship and the approach wall. Subsequently the rails were moved bodily forward to provide a further degree of guidance both on a central path and about 1·5ft from the approach wall. As a result the ship did not then leave the rails until the bows were 80ft inside the lock.

It was apparent that by altering the width of the lock the scale of the experiment could be effectively changed in spite of the fact that the boat was unaltered. Although complete geometrical similarity was not obtained, owing to the fact that such quantities as the radius of the bullnose and the length remained unchanged, it was clear that these effects were negligible compared with that of the relative widths of ship and lock. The width of the lock was therefore increased so that the model ship could represent prototypes of 84ft and 80ft beam. In each case the scales of velocity and depth required adjusting accordingly. The new scales were respectively 1 : 126 and 1 : 120.

Under certain circumstances it became apparent that forces due to surface tension were at least as great as those resulting from the flow pattern around the ship. Generally speaking the effect of surface tension was most marked at the lowest speeds, and with the vessel near one wall. When surface tension is likely to have an overriding effect in the model, the results obtained cannot be expected to be capable of full-scale interpretation. This effect was measured by two methods: (*a*) by a simple system of pulleys and weights, and (*b*) using a sliding rider and applying the principle of the force triangle. By observing the speeds at which surface tension was just overcome by the action of pressure due to the flow distribution, it was possible to form an estimate of the shearing forces involved in Nature. If water alone were used, only one value would be determined for any given condition of approach.

Attempts were made to vary the surface tension by coating the surface with a number of different organic surface agents, e.g. ether and paraffin. Little success, however, attended these experiments because the large surface area of the flume made uniform coverage difficult. It may be shown theoretically that the attraction between two parallel plates immersed in a liquid varies as the inverse of the square of the distance between them. This was approximately confirmed by observations taken with the ship at various distances from the wall. The only satisfactory method of eliminating scale effect due to capillarity, it was concluded, was to increase the size of the model. It is impossible to calculate the ideal size, but it should be as large as circumstances and space permit.

Tracings made from the experimental records all showed the same general trends, i.e. a tendency for the boat to sheer towards the port side. It was found that this yawing persisted even when the boat was guided until just inside the entrance. The violence of this motion

apparently depended in some way upon two factors : (*a*) the ratio of ship sectional area to lock sectional area, and (*b*) the approach velocity. As the speed increased or the free space under the vessel decreased, greater instability ensued. Since, in practice, the ship would always be fully loaded when entering the lock, the only possible way of providing more free space, it was concluded, was by locking at high tide. From the foregoing tests it seemed likely that any method of providing more free space would be equally effective. This, however, was not borne out by experiments using beams of 80ft, 84ft and 88ft, which indicated that these small changes in the width of the vessel had much less influence than the comparatively large alterations encountered in the depth. Finally, the seaward wall was completely removed to give a free surface on one side of the ship. Sheering of the tanker to the port side still occurred but in a greatly diminished form. One trial was carried out using a number of different rudder settings. The trace showed that the rudder had very little influence on the path of the vessel at the speeds employed.

Oil-Handling Equipment

Three of the berths at the oil dock have been equipped with steel gantries which carry the oil pipes, and on each gantry two derricks have been provided for handling the flexible pipes which form the connection between the ship and the shore pipelines. Provision has been made on the fourth berth for the rapid erection of a similar gantry when it is required. One of the gantries is shown in the illustration on this page.

As a precaution against fire, "oil weirs," have been installed. They consist of grilles set at the four corners of the dock. If oil should spill from a tanker a "reverse penstock" goes into action and removes the surface mixture of water and oil into a system of chambers in the dock walls.

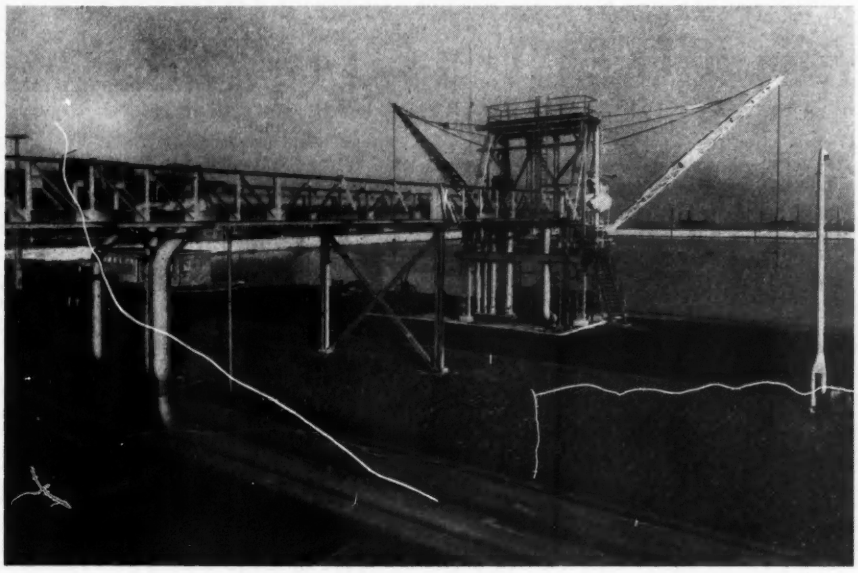
Each oil weir comprises a chamber in the dock wall divided into two sections, one for separating the oil and the other for storing it after separation. The separating chamber is constructed with its long side parallel to the dock wall. At one end is a 4ft by 3ft inlet from the dock, controlled by a penstock which either closes the chamber completely from the dock or acts as a weir to allow only the top surface of the oily water to enter when it is necessary to clear oil from the dock surface. After passing over this weir the oily water falls through a distribution box containing small scrap iron, the purpose of which is to break up water-in-oil globules, to agglomerate small oil globules into larger ones, and to give quiescent entrance to the separating chamber.

Water is constantly drawn off by a pump from the bottom of the chamber at the opposite end to the penstock weir, and so a continuous flow of oily water passes into the chamber over the weir. During this flow through the chamber the oil globules rise to the surface, and when a fair quantity of oil has been separated the water pump is stopped and the weir raised to close off the chamber from the dock.

Water from the fresh water mains supply is then let into the separating chamber at a low level, causing the oil level to rise and the oil to flow over a masonry weir, running the full length of the chamber, into the oil storage chamber. From this oil storage chamber the oil is pumped into the Oil Company's pipe system. Should by chance any water flow into the oil storage chamber, a drain is provided to let it back into the separating chamber. To reduce the danger from explosive gases, both the operating platform carrying the electric pumps and the flooring at quay level consists of open grid steel flooring, and all the electrical equipment is flameproof.

Another safety precaution in the oil-handling equipment of the new dock is the provision of "drip trays," installed where the flexible hoses from the ships connect to the pipe manifolds on shore. Any oil which escapes here is led back by gravity into the oil weirs.

Because of the importance of power to operate the dock machinery, duplicate electric cables are installed, ensuring that the dock is always connected to the grid system. In case of a failure in the main power-house there are three diesel engines. If the double electric hydraulic stage pumps go out of action, the diesels can take over and supply pressure to the power mains. Telephones are installed at each berth enabling a ship's captain to plug directly into the company's dial system. Around the dock there are also an 11kV main, a 12in ring main for fire-fighting, and a 9in main for taking fresh water to the ships. A direct telephone line is connected permanently to the nearest fire brigades in Cheshire ; and there are foam units at each berth.



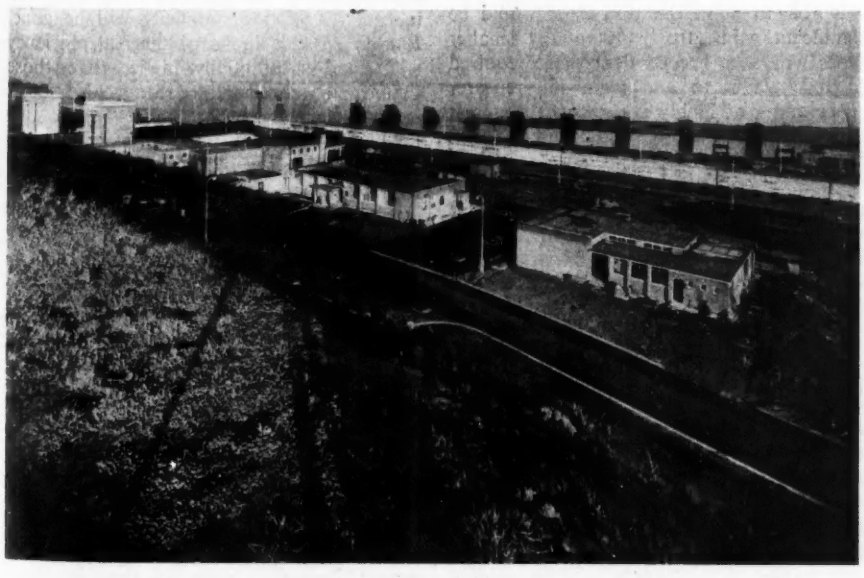
Oil Unloading Gantry

Construction of the new oil dock was started in 1949. The dock was designed and erected under the supervision of the chief engineer of the Manchester Ship Canal Company, Mr. D. C. Milne, M.I.C.E., and his staff. The civil engineering contractor was Sir Alfred McAlpine and Sons, Ltd.; Vickers-Armstrongs, Ltd., supplied the three caisson gates, their operating machinery and the sluice doors ; Richard Sutcliffe, Ltd., supplied the conveyors. The pipeline gantries were built by John Smith (Keighley), Ltd. The cost of the dock was about £5,750,000.

The Opening Ceremony

At the opening ceremony of the dock last Tuesday, the tanker "Velletia" moved into the dock from the entrance lock, breaking the ribbon as she came in. An announcement was then made by Sir Leslie Roberts, chairman and managing director of the Manchester Ship Canal Company, who said that the dock was to be known as the "Queen Elizabeth II" Dock. As the "Velletia" moved into the dock, a sixteen gun salute was fired, and a squadron of "Meteor" aircraft flew over the dock, dipping in salute.

At the luncheon following the opening ceremony, the toast of "Our Guests" was proposed by Sir Leslie Roberts ; Mr. F. J. Stephens, managing director of the Shell Petroleum Company, Ltd., and of the Anglo-Saxon Petroleum Company, Ltd., responded. A toast to "the new Elizabethan age" was proposed by the Lord Mayor of Manchester, and Alderman A. Moss also spoke.



Entrance Lock to Oil Dock at Eastham

Books of Reference

Manual of Mechanical Power Transmission. Third edition. London : Trade and Technical Press, Ltd., 65–66, Chancery Lane, W.C.2. Price 51s.—The new edition of this useful work of reference has been extensively revised and new chapters added to cover the developments in mechanical transmission which have taken place since the publication of the last edition some seven years ago. Its contents are divided into twelve main sections dealing with bearings, belting, chain drives, compressed air, couplings and clutches, gears, hydraulic transmission, pulleys, rope drives, shafting, and vee belts and vee ropes. Each section is well illustrated and a number of useful tables are incorporated. The manual concludes with a buyers' guide of power transmission equipment.

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FUTURE DEVELOPMENT OF MARINE MACHINERY

What a remarkable lecture it was that Dr. Brown, research director of Pametrada, delivered last Friday before the Institution of Mechanical Engineers! Research men, perhaps, have an advantage in delivering a lecture in that as soon as they speak of their own work they must necessarily look forward into the future into which all of us delight to peer. They are interested in contemporary practice, which is the present and abiding concern of most engineers, only as the mere foundation upon which they can build the future. Moreover, much better than other men, if only for the reason that they know in what direction their own work is trending and how the work of other research men may be diverging from it, they can hazard prophecies about the line technical development will probably take. Of course, they are far from infallible. Indeed, the besetting weakness of research workers is undue optimism. It is an inherent and essential weakness. For there can be little place for pessimism amongst people whose job it is to press forward with technical advances; and without an enthusiastic conviction that the difficulties which prevent a more immediate advance can in some way be overcome or evaded a research and development engineer had much better transfer to some other field of activity! But that conviction may lead workers astray, make them forget that the use of a new method or new device must be not merely possible but practicable for ordinary engineers to operate and to maintain, and make them overlook the economics of its operation. Upon that score at least, allowing for the very desirable ebullience of the research worker, Dr. Brown seems to us to have kept reasonably close to earth, though the more conservative, observing references to steam temperatures of 1500 deg. Fah. and gas turbine operation at 2200 deg. Fah., not to speak of liquid metals as heat transfer media, may think otherwise.

The first part of the lecture, which we reprint in abstract in this issue, was confined to a study of the prospects of the future development of steam turbines. A review of present practice in marine design and, more especially, land design, acts as a starting point for the consideration of the developments needed to permit higher temperatures to be used. The top temperature of a practicable cycle is shown to be limited by the physical qualities of the material from which superheater tubes could be made. Looking at least as far forward as the present development of materials permits, a marine installation designed for 1500 lb per square inch and 1500 deg. Fah. is envisaged with two stages of reheat back to 1500 deg. Fah. The boiler would have pressure combustion and high gas speeds and for marine use it is suggested that reheating might be performed by using sodium or sodium-potassium alloy metal as a heat transfer medium. That latter suggestion for the use of a highly dangerous fluid may produce a shudder of aversion amongst marine engineers. Yet Dr. Brown was able to point out that there would be significant gains, that substantially smaller pipes would be needed than those required to take steam to and from the reheater tubes and that highly superheated steam at high pressure is a dangerous fluid in itself. Moreover, the use of liquid metal may very well become normal practice in the development of nuclear power plants. Turbine designers, unquestionably, would be glad to be rid of the need to install astern turbines. It is therefore a point of singular interest that Dr. Brown believes alternative means of achieving astern rotation of the propeller shaft would cost less than that of the special piping, valves and astern turbine casings of a high temperature marine set. One, amongst his solutions, would be the use of epicyclic reduction and reverse gear, by no means a revolutionary suggestion now that epicyclic gearing is becoming widely employed for smaller powers. In next week's issue that part of the lecture that covers gas turbine developments will be printed. It is, of course, obvious that if the gas turbine is to compete with the steam turbine upon an equal footing it must be capable of utilising residual fuel. Experiments undertaken with the 3500 h.p. Pametrada marine gas turbine have shown that a suitable inhibitor may be able to prevent serious fouling of the turbine blades. That point disposed of, Dr. Brown went on to consider the possibilities of really high temperature operation, studying in particular various means of cooling blades and nozzles. That study is necessarily theoretical, though it is no doubt founded upon practical investigations going forward at Pametrada. But the lecturer was able to report that a single-stage turbine to operate at 2200 deg. Fah. is now under construction for the Admiralty. The interesting point emerged that fewer strategic materials would be needed in the construction of a hot gas turbine with liquid cooling than for that of an uncooled turbine operating at 1200 deg. Fah. Again, in this section of the lecture, Dr. Brown stressed the advantages of liquid metal as a heat transfer medium, to operate as the connecting link between separate gas and air heat exchangers.

It is a far cry from the simplicity of the Scotch boiler and reciprocating steam engine to Dr. Brown's conception of future marine machinery; and it may well be exclaimed that the complications of high temperature cycles, reheat, and the use of liquid metal heat transfer media are not to be tolerated on shipboard. But the virtues of simplicity are easily over-stated. It often places responsibilities on human shoulders that would be much more reliably borne by a mechanism! Complication is only a defect if it leads to unreliability, high maintenance costs and difficult control problems. Perhaps Dr. Brown's conceptions will suffer those disabilities. But one thing is certain. The limit for steam turbine temperature is set by the ability to find materials capable of withstanding superheater tube stresses. But there is no such limit to the gas temperatures that can be used in gas turbines where the fuel is burnt directly in the working fluid. If the gas turbine can be adequately cooled, automatically and reliably, and if it can be made to burn residual fuels without deleterious effects upon performance, then, indeed, its pristine simplicity will be gone. But its possible limits of thermal efficiency will stand substantially higher than those that can be contemplated for steam machinery. The "Ifs" may be big ones. No doubt engineers-in-charge, manufacturers and users and those who are hoping to develop steam and gas turbines along lines different from those favoured by Dr. Brown will have much to say about them. But the objective is well worth striving after.

BRITAIN'S ATOMIC FACTORIES

The short, though eventful, history of the growth of Great Britain's atomic production industry is told for the first time in a book, *Britain's Atomic Factories*, published last Monday by Her Majesty's Stationery Office. This industry sprang from the contribution made by British scientists to the military applications of atomic energy during the war, when, because Britain's resources were already fully extended, the joint effort of the research and production of the atomic

bomb was concentrated in the U.S.A. It was not until after the war, however, that the Prime Minister was able to announce the setting up of an organisation to produce fissile materials, whereby this country might take speedy advantage of technical developments in the use of the new source of energy. In the meantime, the passage of the McMahon Act by Congress virtually ended the wartime collaboration on atomic energy between Great Britain and the United States. Britain's atomic energy production programme, therefore, started " from scratch " on February 4, 1946, when the production division at Risley, Lancs, began with a nucleus of " a dozen men and women only one of whom had any knowledge of atomic energy."

From this modest beginning, with a small headquarters in Risley, there grew up in a few years a group of three factories for the production of fissile materials. The first of these factories is a plant at Springfields, Lancashire, for extracting uranium from its ore by chemical processes involving solution in acid and filtration. The whole installation was designed, built and brought into production in two and a half years. In the meantime, work was begun at Windscale, in Cumberland, on the second project, a plant for producing plutonium from uranium in two atomic piles and for chemical separation of the product. While the experience of Harwell was available for the design of the piles, the design and construction of the separation plant had to be based, perforce, on results and inferences derived from laboratory scale experiments. Not the least of the ancillary problems that had to be solved was that of disposing of radio-active effluents, and the book under review describes how the requirements were met by laying on the sea bed two 12in diameter pipes with their discharge ends about 2 miles from the beach. Plutonium was first produced at Windscale only four and a half years after the site had been occupied. The third factory in the Risley group is at Capenhurst, Cheshire, where the fissile uranium 235 is separated from the more abundant isotope, uranium 238. This brief outline does scant justice to the past work of Risley. Each of the factories was designed and built stage by stage before precise details were available of the plant that was to be installed. Each factory was completed within three or four weeks of the programme dates and in each instance the final costs, we are told, were within a few per cent of the estimated sums. In all it is an achievement of a very high order, accomplished with slender resources and with an exemplary economy of effort. Risley can, indeed, look back on seven years well spent on the first task of establishing the means for manufacturing fissile material and can therefore look forward with confidence to the future tasks of using the materials for the generation of power. For the first step, Risley is building an experimental atomic power station at Calder Hall, alongside the Windscale plant, where the reactor will be a pressure-gas-cooled power converter, producing power as well as plutonium from a uranium-graphite pile. Carbon dioxide will be used as coolant because of the scarcity of helium, and will raise steam in boilers to drive a turbo-alternator of conventional design. The next stage in the programme will be to design and build a prototype fast reactor for " breeding " as well as producing power. From the experience gained with these plants it should be possible to assess the relative merits of the three main kinds of reactor—power converters, power " breeders " and simple power producers—and the means of removing the heat for power generation. A longer term objective, which is believed to be capable of being realised in twenty years, might be the establishment of a system of reactor plants to generate enough electricity to save 20,000,000 tons of coal a year, which is the estimated amount by which coal production may fall short of demands during the next twenty years. Such a programme would involve prodigious capital expenditure, but it is considered to be feasible.

There is little to be gained by contemplation of the more distant future of atomic power. We should perhaps be more concerned with the present significance of *Britain's Atomic Factories*, not merely because of the information given but rather because of the prospect that a much greater flow of information is likely to follow. The book marks a stage in the slow and painful process of dissociating the peaceful from the military atomic requirements. It should now be possible to throw open for free discussion many aspects of atomic power production, so that the knowledge and " know how " hitherto confined to a few may be widely disseminated among many and may be allowed to flourish through the interplay of fresh ideas. Co-operation should be sought from those industries that are able and desirous of studying what part they might play in the new developments, so that use can be made of existing specialised knowledge and skills, and the maximum contribution be made by the country's limited resources. What is wanted, above all, to produce conditions favouring healthy growth of industrial atomic power is a considered change from the attitude " Is it safe to tell ? " to that of " Can we afford not to tell ? "

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

" VERMUYDEN AND THE FENS "

SIR,—The review published in your issue of January 1st on Mr. L. E. Harris's book on *Vermuyden and the Fens* certainly lives up to the long-standing tradition of making Vermuyden the villain of the piece. In his onslaught on Vermuyden, I feel that your reviewer has not given an altogether fair impression of Mr. Harris's book, and his anxiety to show Vermuyden in an unfavourable light has led the reviewer to make some curious observations on the technical side of the drainage of the Fens.

Mr. Harris, in his book, says that " Vermuyden was no paragon of virtue, and no attempt will be made to show that he was." What Mr. Harris has done, I think, is to produce such facts as are available about Vermuyden and to give him credit, which is his due, for the successful execution of the largest drainage scheme which has ever been done in England up to the present day. Mr. Harris also shows that Vermuyden's 1638 proposals were exactly the same in principle as those which were advertised for public tender in your issue of January 6th.

On the moral issue, I do not propose to say much, but if the drainage of the Fens was morally wrong and injustices were thereby caused, surely the responsibility for this rests with King James I, Charles I, Cromwell and Parliament in sanctioning the works and, secondly, with the Earls of Bedford and their associates who carried them out ? The dispossession of people enjoying the common grounds of the Fens may have caused some injustice, but surely to a lesser degree than the enclosures which took place in the eighteenth and nineteenth centuries, promoted for the most part by large landowners for ends which were not altogether unselfish. Vermuyden was not a contractor for the works, as stated in the review. The works were not done by contract, but by direct labour. Vermuyden was the engineer who designed and carried out the works, although there seems no doubt that he was not able to carry out the works as he originally intended in his discourse of 1638.

Your reviewer makes the surprising statement that the New Bedford River was cut to help to drain the water from the North Level into the Ouse below Denver. As the North Level is north of the Nene, it is impossible to understand how it could have this effect. He states further on that the Bedford River and the Hundred Foot were beneficial to the North and Middle Level, but left the South Level in a more perilous state than before. I do not understand how it can be suggested that the new cuts would have any effect on the North Level, which is north of Moreton's Leam, and as to the Middle Level, the effect would, if anything, be detrimental rather than beneficial, since it would increase the low-water levels at the mouth of Salter's Lode. It was, however, essential to the drainage of the South Level, which your reviewer claims that it damaged.

Your reviewer states that the diagram of Vermuyden's scheme shows a cut-off discharging into the Ouse, but no relief channel, and that such a cut-off would be of little value to the South level and would spoil the drainage of the North and Middle Levels and that the relief channel was never carried out even if projected. The reproduction of Vermuyden's plan clearly shows the relief channel entering the tidal river near Stow Bridge, and this is correctly reproduced in the diagram. This part of the work was, in fact, carried out, and the remains of it exist to-day. It was a channel having a width of 120ft. I do not understand how it can be said that the making of the cut-off channel would have any adverse effect upon the North Level, and still less how it can be thought that it would not have relieved the flood levels in the South Level. This cut-off channel is, in fact, an essential part of the scheme which the River Board is about to commence.

With regard to the extent of the relief channel projected by Vermuyden, I would point out that the Fen level in his day was about 15ft higher than it is to-day, and for the drainage conditions with which he was dealing, his relief channel would have been adequate in length. To my mind, if Vermuyden's 1638 proposal had been carried out, the subsequent history of Fen drainage would not have been such a sad story as in fact it has been.

W. E. DORAN,
Chief Engineer,
Great Ouse River Board.

Cambridge,
January 12th.

LOCOMOTIVE TESTING AT SWINDON

SIR,—I see that your correspondent " Pyrotechnic " has sent off another volley, but those with real knowledge of British Railways appreciate that beneath all the political and administrative upheavals, Commissions, Executives, and so on, the vast majority of railwaymen have carried on with the job of running the trains with the old loyalty to their chosen calling. THE ENGINEER exists to record the work of engineers, in whatever circumstances they are

working, and if good work continues to be done by those serving nationalised industries I hope it will continue to receive the favourable comments it deserves in your columns. No practical railwayman would ever stop to consider carrying the practice of " constant evaporation " running to the extreme suggested by your correspondent. The absurdity of the suggestion is entirely his own.

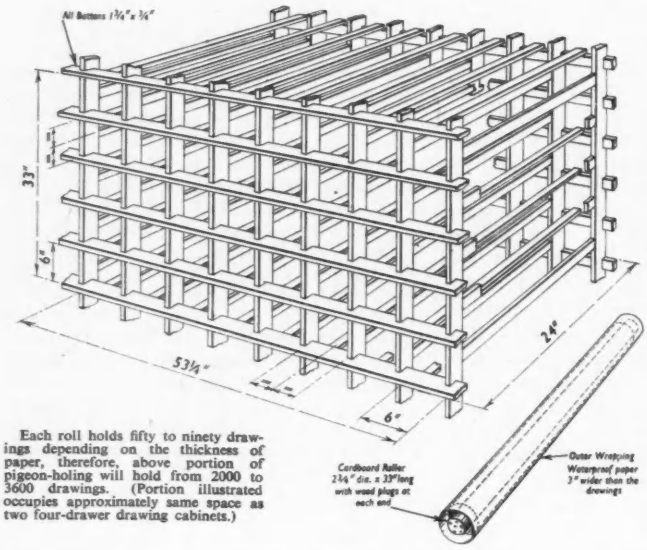
O. S. NOCK

Bath, January 5th.

STEAM LOCOMOTIVE IN AMERICA

SIR,—I have been much interested in your review of the book written by my friend, A. W. Bruce, for many years with the American Locomotive Company.

I have myself read this work with pleasure and the greatest interest ; further, I may perhaps say that I was mainly instrumental in having it made readily available to readers in this country. For this reason, therefore, I am pleased you think well of what, to my mind, is an excellent account of the development of steam motive power in the United States. A book which actually deals in such an authoritative manner with the " Alpha and Omega " of this subject is surely unique and will possibly remain so. The author in his active life was a designing engineer, working in association with J. B. Ennis, a locomotive engineer and designer of eminence, well and favourably known to all locomotive men. I fancy from your remarks you would like to have seen more on the subject of performance ; however, I think you may, on giving the matter " second thoughts," conclude that the author, by reason of his calling, wished only to confine himself to developments in design and construction, which has been accomplished with conspicuous success. The chapter on the development of various locomotive types is of interest as bringing out the " whys and wherefores " of the different wheel arrangements adopted to meet developing traffic demands. Taking, for instance, the " Atlantic," springing from the 4–2–2 through the 2–4–2, which quickly gave place to the 4–4–2 " Atlantic " about 1894/5. This type very soon attained a large measure of success at the hands of S. M. Vauclain, of Baldwins, as THE ENGINEER may have good reason to remember in view of the slight " storm " that sprang in 1896, involving Vauclain and the editor, regarding the performance of a Baldwin-built Vauclain compound " Atlantic " on the Chicago, Milwaukee and St. Paul Railway. Though a somewhat youthful enthusiast at the time, I well remember this historic episode.


All Battens 1¾" x ¾"
33"
6"
53¼"
24"
6"
Cardboard Roller 2¾" dia. x 33" long with wood plugs at each end
Outer Wrapping Waterproof paper 3" wider than the drawings

Each roll holds fifty to ninety drawings depending on the thickness of paper, therefore, above portion of pigeon-holing will hold from 2000 to 3600 drawings. (Portion illustrated occupies approximately same space as two four-drawer drawing cabinets.)

Much could be said about this great effort by A. W. Bruce, every page of absorbing interest. It is a far cry from Stephenson's " America " and Rastrick's " Stourbridge Lion " of 1828 and 1829 to the 6600 h.p. New York Central " Niagara " 4–8–4 locomotives first built at Schenectady in 1945, but the whole story is completely chronicled by the book noticed in THE ENGINEER of December 25, 1953.

E. C. POULTNEY

London, N.W.3,
January 2nd.

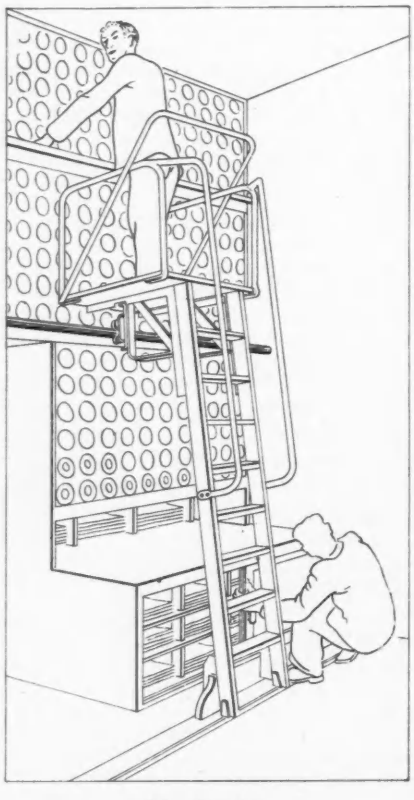
FILING DRAWINGS

SIR,—In your issue of November 27, 1953, a letter from Mr. M. Jones asks for information on drawing storage. The method illustrated by the accompanying sketches can be thoroughly recommended from fifteen years' experience. By this method we store at present 36,000 53in by 30in and 36,000 30in by 20in linen negatives, smaller sizes being kept flat in pigeon holes with sliding dustproof fronts.

The rolling of drawings is often frowned upon and can be very destructive, but the secret of success lies in the cardboard core, and we have had no trouble—in fact, very much less wear and tear than by the use of drawers. The space occupied is reduced to 40 per cent of that required by the flat filing drawers previously used.

Experimental samples had brown linen dust covers, but the quantity required was not available during the war and waste wrapping paper was used and found to be quite good, and also cheaply renewable.

Our drawing curators have had nothing but praise for the method and we shall be pleased to supply Mr. Jones with any further information which may not be clear from the sketches.



Filing Drawings

H. G. PARKER,
Assistant Chief Engineer,
Short Brothers and Harland, Ltd.

Belfast,
January 1st.

PERFORMANCE OF CARS

SIR,—Mr. W. H. Devenish, in his letter dated December 1st, asks for the comparison of motor-cars by overall efficiency. I am sure Mr. Devenish does not realise that the public who, to a great extent, are quite ordinary people and are not concerned with efficiency in the sense mentioned, but what they are really concerned with is mainly (1) miles per gallon obtained with petrol, (2) acceleration, (3) room available in vehicle.

For instance, I have a 12 h.p. car fitted with a six-cylinder engine with a petrol consumption of 36 miles to the gallon—what worry have I with efficiency or any other person with a similar car ?

I do not want to be bothered with 15 to 25 per cent efficiency, all that concerns me is a reasonable petrol consumption, &c.

I hope you kindly spare room in your journal to publish this.

STANLEY ROGERS

Ferndown,
January 13th.

TWO MARINE WATER-TUBE BOILERS

SIR,—I should like to comment upon two statements made by Mr. G. A. Plummer in his contribution to the discussion of the above paper as reported in THE ENGINEER for November 20, 1953. These were :—

(1) " Very small percentages of CO_2 give rise to much greater conductivity than do equivalent percentages of boiler salts, so it appears unlikely that this apparatus would be sufficiently sensitive to provide a satisfactory indication of carry-over."

This is not true. CO_2 is only slightly ionised in water and its effect upon electrical conductivity of condensate is negligible by comparison with the sharp rise that occurs when boiler salts pass over with the steam. Even if CO_2 in water was a good conductor, which it is not, the fact could not invalidate the use of a conductivity device for detection of priming because the reading due to CO_2 would remain fairly constant and carry-over would still result in a conductivity well above the norm.

(2) " A large number of boilers at power stations in this country and a number of marine installations are using sodium hydroxide for provision of alkalinity in boiler water and thus avoiding unnecessary sources of CO_2."

As one who can claim to be conversant with present-day practice at power stations and at large boiler installations of all types, I should say that the addition of caustic soda to boiler feed water is the exception rather than the rule. The usual source of alkali nowadays is trisodium phosphate, which does not decompose to liberate a corrosive gas such as CO_2 and is free from the risk of causing intergranular cracking by what used to be known as " caustic embrittlement." In those relatively few instances where caustic soda is still preferred for some special reason or other, care is always taken by competent persons in charge to ensure either that the caustic alkali is neutralised inside the boiler with a glassy phosphate such as sodium hexametaphosphate or that the ratio for prevention of embrittlement which balances the causticity against a large excess of sulphate is consistently observed.

W. F. GERRARD, F.R.I.C.
Technical Department
Feedwater Specialists Company,
Liverpool, 3, January 9th.

Shipbuilding and Marine Engineering in 1953

No. IV—(*Concluded from page 92, January 15th*)

Oil Tankers

THE preponderance of oil tankers on the order books of British shipyards, which has persisted during the post-war years, continued during 1953 and represented over 50 per cent of the tonnage delivered.

The largest tanker completed during the year was "World Enterprise," of about 32,000 tons deadweight, built at the Naval Yard of Vickers-Armstrongs, Ltd., for the World Tankers Corporation. The ship has a length between perpendiculars of 635ft by 86ft moulded breadth by 45ft 9in moulded depth, a load draught of 34ft 5in and a service speed of 16 knots. Cargo oil is carried in ten triple tanks and there is one main pump-room, located immediately forward of the machinery space, containing three horizontal centrifugal pumps, each having a water capacity of 1000 tons per hour, and driven by turbines situated in the engine-room. Also in the pump-room are two 150 tons per hour, steam-driven, vertical stripping pumps. The main propelling machinery consists of one set of double reduction geared turbines of Pametrada design built by Parsons Marine Steam Turbine Company, Ltd., and developing a normal service power of 12,500 s.h.p. at 100 r.p.m. of the propeller and a maximum of 13,750 s.h.p. at 103 r.p.m. The h.p. turbine of impulse pattern and the l.p. turbine of reaction design take steam at 850 lb per square inch and 850 deg. Fah. from two Foster Wheeler "D" pattern water-tube boilers, built by Richardsons, Westgarth and Co., Ltd., operating under Howdens forced draught. Steam-driven deck machinery is fitted and power for the other auxiliaries is provided by two 500kW turbine-driven alternators.

London and Overseas Freighters, Ltd., took delivery of the 24,600 tons deadweight tanker, "London Splendour," from the Furness Shipbuilding Company, Ltd., and this ship has the following dimensions: length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, summer draught 32ft 3½in. A high standard of accommodation has been provided and an extra deck added to the midship deckhouse to allow four two-berth passenger cabins to be fitted. There are a total of twenty-seven cargo oil tanks and two pump-rooms, in each of which are two 500 tons per hour horizontal duplex pumps and a stripping pump. Steam-driven deck machinery is installed and the electrical power plant consists of two 75kW steam-driven generators and one 35kW diesel-driven generator. The ship is propelled at a speed of 14 knots by a single-acting, two stroke Wallsend-Doxford oil engine having six cylinders of 670mm diameter by 2320mm combined stroke and developing a power of 6600 b.h.p. in service at 116 r.p.m. It is of interest to note that the main engine pumps are chain-driven through mechanical clutches and a speed increasing gearbox from the intermediate propeller shaft, while the steam for the auxiliaries is supplied by two Scotch boilers.

In Plate 2 in our issue of January 8th we illustrated the "Atlantic Baroness," which has a length between perpendiculars of 545ft by 71ft breadth moulded and a depth moulded of 40ft 6in. The ship, which carries a deadweight of 19,500 tons on a draught of 31ft 1in, was built and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., for Atlantic Oil Carriers, Ltd. Three 680 tons per hour horizontal turbine-driven pumps for dealing with the cargo oil are fitted in the pump-room, together with two stripping pumps of 180 tons per hour capacity. Most of the engine-room auxiliaries are electrically driven and power for these is developed by two 250kW turbo-generators while there is one 60kW diesel-driven generator for harbour use. A single set of double reduction geared turbines, consisting of an h.p. impulse turbine and a single flow l.p. reaction turbine, drive the ship and take steam from two Babcock and Wilcox water-tube boilers.

Also shown in Plate 2 of January 8th was the single screw tanker "Polartank," constructed by Barclay Curle and Co., Ltd., to the order of Melsom and Melsom of Norway. The ship has a length, breadth and depth of 566ft by 72ft 6in by 40ft 6in

Diesel Electric Pilot Tender "Edmund Gardner"

respectively, and carries a deadweight of 19,000 tons, while the cargo oil is handled by four steam pumps arranged in two pump-rooms. Two cylindrical multi-tubular boilers provide the steam for the deck machinery and other auxiliaries and the main propelling machinery consists of a Barclay Curle-Doxford oil engine having six cylinders of 750mm bore by 2500mm combined stroke and fitted with a Doxford Bibby detuner at the forward end of the crankshaft.

One of the large number of general purpose tankers on order at a number of shipyards for Shell Tankers, Ltd., is the "Helix," which was built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd. This ship has a length between perpendiculars of 530ft by 69ft 3in moulded breadth by 39ft depth moulded and carries a deadweight of 17,780 tons on a load draught of 29ft 8⅝in at a service speed of 14½ knots. A number of innovations are embodied in the ship, including fluorescent lighting, an overside lift and a pressurised air ventilation system throughout the engine-room and boiler-room and certain rooms in the accommodation so that naked lights can be used without danger of an explosion occurring. A double ring main pipeline is fitted in the tanks and there are four 400 tons per hour, turbine-driven, cargo oil pumps in the main pump-room arranged at the aft end of the cargo oil tanks and adjacent to the machinery spaces in which the turbines for the pumps are located. The main propelling machinery, supplied by the British Thomson-Houston Company, Ltd., is of turbo-electric design and consists

Clyde Ferry "Maid of Ashton"

of a propeller motor having a maximum output of 8300 s.h.p. at 103 r.p.m. and a normal service power of 7500 s.h.p. at 100 r.p.m. Power is developed by two alternators, each having a normal rating of 2900kVA at 3000 r.p.m. and a maximum rating of 3200kW at 3090 r.p.m. and driven by a nine-stage impulse turbine. Two Babcock and Wilcox integral furnace boilers, designed for a working pressure of 450 lb per square inch and a temperature of 750 deg. Fah. and operating under Howden's forced draught system, supply the necessary steam. Two 550kW turbine-driven alternators provide the necessary current for the engine-room auxiliaries and there is one 200kW diesel-driven alternator for emergencies.

Pilot Ship "Wyuna"

Among the ships joining the fleet of Overseas Tankship (U.K.), Ltd., were the "Caltex Canberra," built by the Furness Shipbuilding Company, Ltd., and the "Caltex Manchester" and "Caltex Bahrain," constructed by R. and W. Hawthorn, Leslie and Co., Ltd. The latter ship, illustrated in our issue of last week, has a length between perpendiculars of 515ft, a breadth moulded of 70ft, a depth moulded of 39ft 9in, a deadweight of 17,450 tons and a summer draught of 30ft 4⅜in. There are twenty-seven cargo oil tanks and one pump-room containing three 625 tons per hour turbine-driven cargo pumps and three 200 tons per hour vertical stripping pumps. The electrical plant consists of two 400kW geared turbo-generators, two 50kW motor-driven generators and one 50kW diesel-driven generator, while the ship is propelled by one set of double-reduction geared turbines consisting of an h.p. impulse turbine and an l.p. impulse reaction turbine capable of developing a maximum of 8200 s.h.p. at 104 r.p.m. of the propeller. Two Yarrow three-drum boilers supply steam at 450 lb per square inch and 750 deg. Fah.

Included in our illustrations last week was a photograph of the oil tanker "Baron Kilmarnock," built by the Caledon Shipbuilding and Engineering Company, Ltd., for H. Hogarth and Sons, Ltd. The ship has a deadweight capacity of 16,900 tons on a 30ft draught and the following particulars: length overall 548ft, breadth 71ft, depth 38ft 9in and is propelled by a Kincaid-Harland and Wolff-B. and W. two-cycle, single-acting, diesel engine having six cylinders of 750mm bore by 1500mm stroke and developing 6950 b.h.p. at 110 r.p.m. The cargo oil is handled by four 500 tons per hour horizontal duplex compound, double-acting pumps and two 150 tons per hour stripping pumps arranged in two pump-rooms.

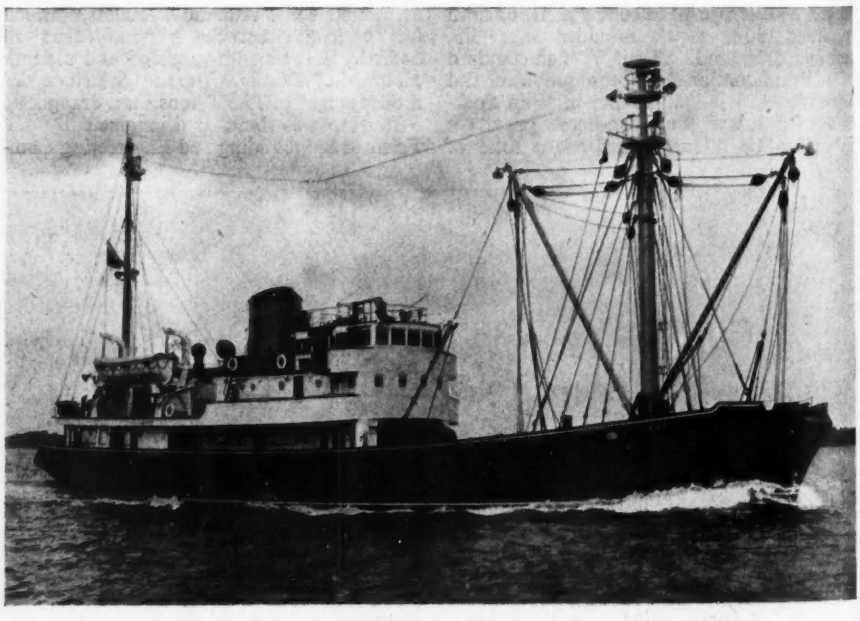
Another example of a tanker in the 16,000-ton class is the "Alva Cape," which was illustrated in our issue of last week and was constructed by the Greenock Dockyard Company, Ltd. This ship has a length between perpendiculars of 512ft by 69ft breadth moulded by 38ft 6in depth moulded and has a deadweight capacity of 16,590 tons on 29ft 10¾in mean draught. Two 400 tons per hour cargo oil pumps and one 60 tons per hour stripping pump are fitted in each of two pump-rooms to handle the oil carried in the twenty-one cargo tanks. Propulsion is by means of a Scott-Doxford oil engine having six cylinders of 670mm diameter by 2320mm combined stroke and developing 6600 b.h.p. at 114 r.p.m.

Among the ships which joined the fleet of the British Tanker Company, Ltd., was the "British Flag," built by R. and W. Hawthorn, Leslie and Company, Ltd., and shown in our photograph reproduced on Plate 2 of our January 8th issue. The deadweight is about 16,200 tons and the cargo oil is carried in twenty-seven tanks served by two pump-rooms, each equipped with two duplex compound pumps. The ship has a length overall of 547ft, a breadth moulded of 69ft 6in, a depth moulded of 37ft 6in, and is powered by a six-cylinder Hawthorn-Doxford oil engine of 6400 b.h.p. at 115 r.p.m.

Harland and Wolff, Ltd., completed a large number of oil tankers during the year, including the "Clydefield," for Hunting and Son, Ltd., a ship of 16,500 tons deadweight powered by a six-cylinder Harland-B. and W. opposed piston oil engine, and the "Irex" for Norwegian owners. This ship, which we illustrated last week, has a deadweight of 12,000 tons on 27ft 6in draught and the following dimensions: length between perpendiculars 460ft, breadth moulded 59ft, and depth moulded 34ft 10in. There are twenty-four cargo oil tanks, two pump-rooms, and the propelling machinery consists of a Harland-B. and W. single-acting, four-stroke diesel engine having six cylinders of 740mm bore by 1500mm stroke.

The R.F.A. oil tanker "Eddycliff" was built for the Naval Store Department of the Admiralty by the Blythswood Shipbuilding Company, Ltd., and the following are the main particulars: length between perpendiculars 270ft, breadth 44ft, depth 18ft 6in, draught 17ft 2¾in, and 2190 tons deadweight. There are twelve cargo oil tanks and two pump-rooms and the ship is propelled by a totally-enclosed pressure lubricated, steam triple-expansion engine, built by Lobnitz and Co., Ltd., developing 1750 i.h.p. and taking steam at 250 lb per square inch from two multi-tubular boilers.

Another small oil tanker completed during the year was the "Vacuum Pioneer," built by the Grangemouth Dockyard Company, Ltd., for the Vacuum Oil Company, Ltd., for the carriage of lubricating oils between the Coryton refinery and the company's grease manufacturing works. The ship has a length of 245ft by 40ft beam by 16ft 6in depth by 15ft 3in draught and a deadweight of 1640 tons. There are ten tanks and special pumping arrangements to deal with the various grades of oil carried, including four 150 tons per hour cargo pumps and one 60 tons per hour stripping pump. A speed of 11½ knots is given to the ship by a North Eastern Marine direct-acting, reheat, triple-expansion engine taking steam at

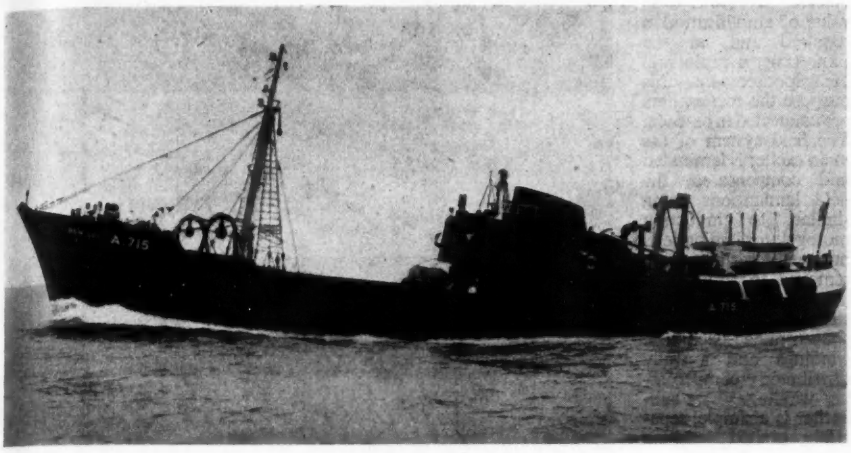


Twin Screw Steamship "Vigilant"

200 lb per square inch from two cylindrical multi-tubular boilers.

A Number of Special Ships

The first of four twin-screw motor passenger ships for the Clyde ferry services of British Railways was the "Maid of Ashton," illustrated herewith, which was built by Yarrow and Co. and can accommodate 627 passengers. Much more sheltered deck space is provided than on earlier vessels and the ship has a length overall of 165ft, a breadth moulded of 28ft, a depth moulded of 10ft, a load draught of 6ft, and a service speed of 15 knots. Two sets of six-cylinder British Polar, two-stroke, diesel engines, each developing 650 b.h.p. at 425 r.p.m. form the main propelling machinery. The ship, which completed her trials in May of last year, was described in The Engineer of June 5, 1953. Another ferry from the same yard was the "Man Fung," a motor passenger ferry, for the Hong Kong harbour services, which was built at Glasgow, dismantled and re-erected at Hong Kong. The "Man Fung" which is one of five such ferries, has a length between perpendiculars of 97ft 1in by 24ft beam by 9ft depth by 6ft 9in draught and carries 650 first and third-class passengers. A service speed of 10½ knots is maintained by a five-cylinder Crossley Mark H.R.L.5/40 diesel engine.



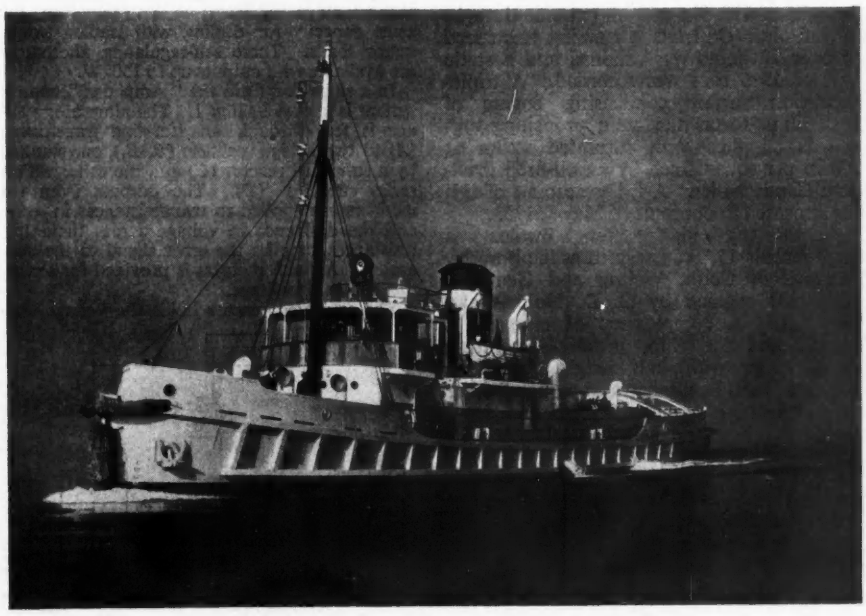
Motor Trawler "Ben Lui"

Philip and Son, Ltd., completed the single-screw diesel-electric pilot tender "Edmund Gardner," for the Mersey Docks and Harbour Board, which is generally similar to the "Sir Thomas Brocklebank," built in 1950 and described in The Engineer of December 1, 1950. A total of thirty-two pilots are carried and provided with comfortable cabins and the ship, which we illustrate, has the following particulars: length between perpendiculars 165ft, breadth moulded 31ft 6in, depth moulded 14ft 9in, and speed 13¼ knots. To satisfy onerous operating conditions, which include working at low speeds only requiring about 3 per cent of the full power, diesel-electric propulsion was chosen and supplied by The General Electric Company, Ltd. The main propulsion motor, developing 920 b.h.p. at 300 r.p.m., is supplied with power from two 375kW generators, each driven by a six-cylinder, pressure-charged, four-cycle diesel engine provided by the National Gas and Oil Engine Company, Ltd. Another example of a pilot vessel illustrated herewith is the "Wyuna," built by Fergson Brothers (Port Glasgow), Ltd., and engined by the English Electric Company, Ltd., for the Port Philip Sea Pilots Association. The following are the main dimensions: length between perpendiculars 185ft, breadth moulded 39ft, depth moulded to upper deck 22ft 6in, and designed speed 13 knots. There is provision for twenty pilots in two-berth cabins and it is of interest to note that cathodic protection of the hull is provided by the fitting of magnesium anodes to the upper side of the bilge keel. Power for the two 700 s.h.p. electric propulsion motors, which operate at 150 r.p.m., is developed by three 380kW generators, each driven by an eight-cylinder English Electric Mark 8S.R.K. diesel engine, while the auxiliary generating equipment consists of two 150kW and one 50kW diesel-driven generators.

Late in the year Philip and Son, Ltd., completed the research ship "Sarsia" to the requirements of the Marine Biological Association of the United Kingdom for marine biological and oceanographical research and was briefly described in our issue of November 20th last. In addition to the crew, accommodation is provided for four scientists and there are two laboratories and adequate stowage space for the research equipment. The ship has a length overall of 128ft by 28ft beam by 13ft depth moulded, a mean load draught of 9ft 6in and a designed speed of 10 knots. Propulsion is by a diesel engine developing 270 s.h.p. at 450 r.p.m., built by the National Gas and Oil Engine Company, Ltd., and driving through a 3 : 1 ratio reverse-reduction gearbox supplied by Modern Wheel Drive, Ltd., while the low speed for fine net trawling is achieved by the "Woolnough" creeping speed device.

At the Woolston shipyard of John I. Thornycroft and Co., Ltd., the "Vigilant," a twin-screw buoyage, salvage, survey and fire-fighting ship, was completed for service with the Mersey Docks and Harbour Board in Liverpool Bay. The ship, which we illustrate on page 141 and was described in The Engineer of July 24, 1953, has a length between perpendiculars of 160ft, a breadth moulded of 35ft, a depth moulded to main deck of 16ft 6in, a mean load draught of 11ft 1in and a speed of 12·5 knots. The main deck forward forms the main working space and is provided with special bollards, anchorages and a bow fairlead, all capable of taking a 100-ton load, in association with heavy lift derricks. Electric power for the auxiliary and deck machinery is supplied by two 180kW diesel-driven generators and the ship is propelled by two sets of triple expansion engines capable of developing a total of 1450 i.h.p. when supplied with saturated steam at 220 lb per square inch from two oil-fired forced-draught Scotch boilers.

Hall Russell and Co., Ltd., built the "Ajasa," a single-screw, self-trimming collier, to the order of the Crown Agents for the Colonies on behalf of the Nigerian Government. The ship, of raised quarter deck design, carries 4000 tons deadweight on 19ft 3in summer draught and has the following dimensions: length between perpendiculars 330ft, breadth moulded 46ft, and depth moulded to upper deck 21ft 6in. There are four holds served by eight 3-ton and one 12-ton derricks and the propelling machinery, placed aft, consists of a triple-expansion engine of 1850 i.h.p., taking steam at 220 lb per square inch from three cylindrical boilers designed to operate on quick-burning West African coal. The "Guildford," a collier of smaller size and designed to carry coal to the upper reaches of the



Suez Canal Tug "Horus"

River Thames, was delivered to the South Eastern Gas Board by the Burntisland Shipbuilding Company, Ltd. A deadweight of 2875 tons is carried on a length between perpendiculars of 264ft 6in by 39ft 5in beam by 18ft 6in depth moulded and a draught of 17ft 1¼in and there are three large holds for the coal cargo. The deck machinery is electrically driven and the propelling machinery consists of an eight-cylinder British Polar diesel engine developing 1150 b.h.p. at 225 r.p.m.

The whalecatcher, "Setter IX," built by A. and J. Inglis, Ltd., for Hector Whaling, Ltd., has a length between perpendiculars of 173ft, a breadth moulded of 31ft, a depth moulded of 17ft, a designed speed of 16¾ knots and an endurance of forty days at economical speed. The propulsion arrangements are unusual for this class of ship in that twin non-reversing diesel engines drive a Stone-Kamewa three-bladed variable-pitch propeller through gearing and electric slip couplings. The main units are twin National Mark B4.A.U.M.6, six-cylinder, four-stroke, non-reversing, supercharged diesel engines, each developing 1360 b.h.p. at 350 r.p.m. and driving an A.S.E.A. 2 : 1 reduction gear through an A.S.E.A. electric slip coupling. The electrical plant for developing power for the engine-room auxiliaries and deck machinery consists of three 100kW generators, each driven by a three-cylinder National diesel engine.

Our photograph shows the diesel-engined trawler "Ben Lui," built by John Lewis and Sons, Ltd., for Richard Irvin and Sons, Ltd. The ship, which carries a crew of seventeen, has a length between perpendiculars of 147ft 6in, a beam of 28ft and a depth of 15ft 3in. The main engine is of Doxford design constructed by the shipbuilders and is the lowest powered unit yet built. It is a three-cylinder unit having a bore of 400mm by 760mm stroke for the lower piston and 540mm stroke for the upper piston and develops 750 b.h.p. at 145 r.p.m.

A tug for abreast towing of barges was constructed to the order of the Compagnie Universelle du Canal Maritime de Suez by John I. Thornycroft and Co., Ltd., and is illustrated herewith. The "Horus," which is fitted with horizontal and vertical fenders and is specially designed for operating under hot and humid conditions, has a length overall of 138ft by 26ft beam, a mean draught of 11ft 9in and an extreme draught of 13ft 6in. On trials a running free speed of over 12 knots was attained and a static pull of 15·5 tons was recorded. A triple-expansion surface-condensing engine of 1150 i.h.p. forms the main propelling unit and is supplied with saturated steam at 200 lb per square inch by an oil-fired Prudhom Capus boiler. A fuller account of this tug appeared in our issue of May 8, 1953.

Another tug built for French owners was the "Abeille 15," constructed at the Beverley shipyard of Cook, Welton and Gemmell, Ltd., and engined by C. D. Holmes and Co., Ltd. A complement of nineteen is carried and the ship, which is of flush deck design with half height forecastle, measures 125ft length between perpendiculars by 32ft breadth moulded by 14ft 6in depth moulded. Fire and salvage equipment are provided and the main engine is a triple expansion unit capable of developing 1500 i.h.p. at 128 r.p.m., with the ship running free. On trial a mean average speed of 13¼ knots was attained and a static bollard test pull of 18 tons was recorded.

REFERENCE TO THE MONOPOLIES COMMISSION.—The Monopolies Commission is to report on the supply in Central Scotland of sand and gravel suitable for building or civil engineering purposes.

Self-Regulating Alternators with "Amplidex" Control

THE accompanying illustrations relate to a range of self-regulating alternators which have been developed by the Brush Electrical Engineering Company, Ltd., Loughborough. In these machines alternator excitation is obtained (by a system known as "Amplidex" control) from an amplifying dynamic excitation unit which consists of a main exciter to supply the alternator field current and a small sub-exciter, the two being mounted in tandem in a single frame.

To control the alternator from the small power output of the detector circuit a high value of amplification is required and, at the same time, a rapid rate of response. For this purpose the two exciters are connected in cascade. The field system of the main exciter is laminated and compensated, the field laminations being similar to induction motor stator laminations but with certain teeth removed to form commutating zones. The stator is wound with concentrated excitation windings and a fully distributed compensating winding. The sub-exciter is a simple, separately excited machine and has also a laminated field construction.

Compensation is required to enable the exciter to operate with comparatively high armature loading and low magnetising power, this combination resulting in high amplification and quick response. The compensating winding also ensures good commutation during the field forcing required to restore the alternator voltage quickly on sudden changes of load. A damping circuit is included so that the maximum recovery rate can be maintained with stability.

A characteristic of the "Amplidex" control system is that it can be applied to an alternator of orthodox construction. In the equipments described and illustrated here (Fig. 3), the alternator has the normal salient pole construction with large air gaps and normal proportions of field and armature ampere turns as it would if it were required for use with an ordinary automatic voltage regulator; it has, therefore, the same capacity for dealing with leading power factor loads. These self-regulating alternators are available with outputs up to 150kW.

In a simplified form the "Amplidex" control system is shown in Fig. 1. The alternator voltage is fed through an isolating transformer (*A*) to two bridge rectifiers (*B*, *B*₁), one shunted by a saturated reactor (*C*) and the other with a series capacitor (*D*). The outputs from the rectifiers are applied to two resistances in series and the difference in voltage across these two resistances supplies the error signal to the sub-exciter. A small rheostat is provided for setting the alternator voltage.

The saturated reactor holds the voltage constant across one rectifier but the voltage of the other varies in direct proportion to the alternator voltage. When the two voltages are equal no current will be supplied to the exciter field. If the alternator voltage varies the exciter field current will vary in magnitude by an amount depending upon the strength and direction of error signal, thereby rapidly correcting the terminal voltage to its set value.

The reference voltage provided by the saturated reactor is sensitive to frequency but so is the current in the capacitor fed by the rectifier; these two effects are thereby cancelled out and thus no variation due to frequency changes results. The maker states that over the normal range of engine governing, the balance point will remain unchanged, and that the frequency can be adjusted from 50 c/s to 60 c/s with only a small change in voltage.

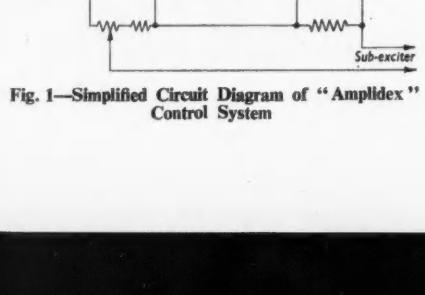
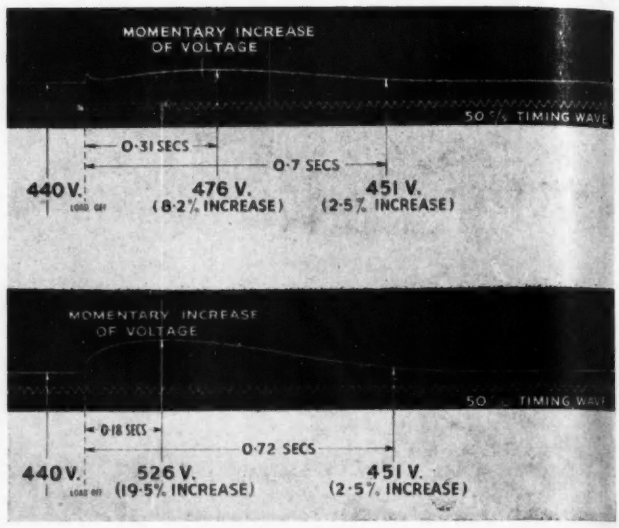


Fig. 1—Simplified Circuit Diagram of "Amplidex" Control System



(Upper) Full load at unity p.f. thrown off.
(Lower) Full load at 0·8p.f. lagging thrown off

Fig. 2—Characteristics of Self-Regulating Alternators with "Amplidex" Control

With this system of control a voltage regulation of ±2½ per cent is specified from cold to hot at variable power factors, from no load to full load, allowing for the usual 4 per cent engine speed variation. When full load at 0·8 power factor is thrown off, the voltage rise is arrested in less than 0·2 of a second and the voltage overshoot is within 20 per cent of normal voltage (lower curve, Fig. 2). Throwing off full load unity power factor is less onerous and very little disturbance of the voltage occurs, as shown in the upper curve, Fig. 2. Up to full rated kVA, voltage recovery is obtained in one second or less for any condition of load change.

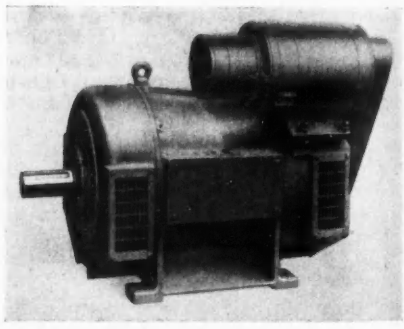


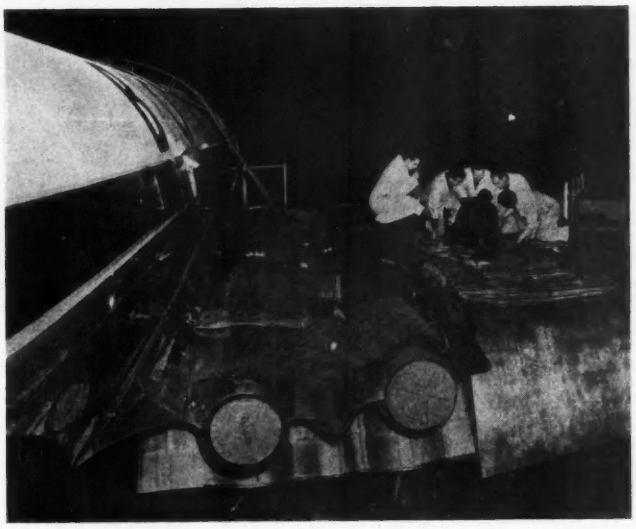
Fig. 3—Self-Regulating Alternator with "Amplidex" Control

The maker states that this system will operate over a voltage range such as 380/440V, and a frequency range of 50/60 c/s. If necessary a series parallel stator connection may be provided to give dual voltage when required. Both voltage ranges are covered by the same rheostat and full rated output is obtained at either voltage.

"Comet" Investigations

IT will be recalled that since Monday of last week all the "Comet" aircraft in operation with British Overseas Airways Corporation have been grounded pending the completion of a "minute and unhurried" examination of each machine. This action had been voluntarily undertaken by B.O.A.C. thirty-six hours after one of its "Comet" fleet had been seen to crash in the Mediterranean Sea. Its structural completeness before striking the water was not clearly established. Eye-witnesses were not agreed whether the machine was on fire, although there was more certainty that an explosion had shortly preceded the crash. No distress signal was received from the aircraft and the weather was considered normal. With so much in doubt as to the possible cause and the circumstances of this accident, and in the light of the disaster to the "Comet" last May near Calcutta, with which there seemed much in common, the decision taken by B.O.A.C. was considered a matter of prudence.

On Saturday last, however, the probability of sabotage was officially referred to by Sir Miles Thomas, chairman of B.O.A.C., who had by then been informed of the considered medical evidence prepared by the corporation's medical staff. This report now assumes a very special significance, for the condition of the victims so far recovered is not considered compatible with any disaster likely to be associated with structural failure, fuel fire or engine disintegration. Even greater importance is now attached to the recovery of the wreck and extensive salvage operations are being planned by the Admiralty.



"Comet" Investigations in Progress at London Airport

Inspection Schedule

The extent of the inspection of the "Comet" fleet was provisionally restricted to a Check 4. This inspection, which has been agreed upon by the makers, B.O.A.C. and the Air Registration Board, differs in several respects from those of other aircraft which enjoy a longer development history. It remains, however, the most comprehensive complete overhaul which the aircraft will normally undergo. It is undertaken every 1200 hours, which is some 200 hours less than is customary with more established piston-engined aircraft.

Every inspection panel and hatch on the aircraft is lifted for this check, it is stripped of all interior fittings, insulation and pressurisation fittings, and much of the paint is removed.

It is necessary, when the number, location and grouping of these inspection panels are being determined, that the Check 4 requirements are fully fixed, for when thus stripped it can be roughly generalised that there must be access to what is considered sufficient of the structural elements in the aircraft wing and fuselage, direct or working access to every prime motivating unit in the control and ancillary systems and at least visual access to the associated linkages so that their condition and alignment can be assessed.

All these systems are checked for correct functioning overall, those parts of components which can be seen in the working condition, such as plungers, pins and bushes, &c., are examined for wear and corrosion, and tests are made for fluid leaks. It is not a general requirement of the Check 4, however, that these units be removed from the aircraft or stripped.

The number of items in the check schedule for the wing and fuselage probably amount to some thousands, but in nearly all cases the inspection aims to establish whether distortion has taken place, the detection of cracks in the skin in the vicinity of holes or welds, whether corrosion has occurred, and to assess the condition of the rivets. Where dynamic loading is more severe and particularly on the tail assembly of high-speed jet aircraft, a particular scrutiny is observed when applying the above tests. In the case of the "Comet" aircraft the removal of specimen bolts from the wing joints is not demanded in a normal Check 4, providing that the wing joints show no evidence of movement or corrosion. One of the main objections to disturbing the wing joint, particularly on aircraft where the rigging incidence is critical, is the inevitable "springing" which occurs at the joint, thus making the task of correctly restoring the joint a difficult one. At the present time the use of crack detectors in this inspection has had a very limited application and has then been mostly confined to those of a chemical form.

Apart from these checks, the continuance of the Certificate of Airworthiness, which is formally granted each year, requires that certain other tests are carried out with cycles of up to 4800 hours' flying. These tests, which are known as the "running" C. of A. tests, are incorporated when they become due with the nearest Check 4 inspection. Generally speaking, their purpose is to ensure that certain structural assemblies, such as the tail unit, are removed from the aircraft and examined in more detail and other working parts are systematically removed and given a complete internal and external overhaul in the workshop. An instance of this is the "servodyne" unit in the tail, which is sent back to the works every 2400 hours.

At the end of last week the Check 4 inspection on three aircraft had been completed and all were found to be completely serviceable. The running C. of A. checks incorporated involved some different part of the aircraft in each case. On one machine the tail assembly was removed, on another the auto-pilot controls, electrical equipment and instruments were broken down more extensively for examination, and certain other special points of the structure were examined. In the case of the third machine a number of special points on the structure were more severely examined. With all these running C. of A. checks, however, the inspection was particularly rigorous and was carried out under the supervision of respective authorities from the Royal Aircraft Establishment, Farnborough.

In deciding to restrict the examination provisionally to a routine major overhaul, the Corporation was influenced by investigations, now nearly completed at Farnborough, on "Comet" aircraft. Here, the parts salvaged from the aircraft which crashed near Calcutta have been under examination for several months. Immediately following that accident the first prototype "Comet" was also despatched to the R.A.E., where it has since been subjected to extensive structural tests. Major structural components, including the wings, have or are in the process of being tested to destruction. Consequently the behaviour of this aircraft will largely determine whether a more extensive dismantling of the operational fleet must be considered. From statements issued by B.O.A.C. up to last Saturday this appeared extremely unlikely.

The possibility of engine disintegration, which might attend the failure of the rotor system in such a prime mover, is at the moment considered to be an unlikely cause of this particular disaster. Although it cannot at this stage be ruled out, no action had been taken up to last Saturday concerning any special examination of the engines in the fleet. The history of the de Havilland "Ghost" turbo jet engines is a particularly satisfying one, and extensive rig testing and operational experience, particularly in military aircraft, has been obtained with them. As a result of the experience gained during the first thirteen months of the B.O.A.C. "Comet" services, the "Ghost" engines operated by both the Corporation and the French company, Union Aeromaritime de Transport, had by last June been officially cleared to operate for 600 hours between overhauls. A batch of B.O.A.C. engines had commenced running a trial extension to 750 hours. At that time "Ghost" engines in service had completed over 60,000 hours. The average B.O.A.C. "Ghost" engine then attained over 85 per cent of its approved life. Many of them had then been overhauled for the third time. Union Aeromaritime de Transport stated that the maintenance man-hours were only about half those required for the piston engines which it also employs.

In the stricken aircraft the engines had completed respectively 360, 536, 492 and 113 operational hours since their last major overhauls.

Engineering and Shipbuilding Wages

LAST week, the courts of inquiry, appointed by the Minister of Labour to examine the facts of the wage disputes in the engineering and shipbuilding industries, began their public hearings. Lord Justice Morris is the president of the courts, the other members being Sir Harold Howitt, Mr. H. Lloyd Williams, Sir Robert Sinclair, and Mr. C. J. Geddes. In both industries, it will be recalled, the dispute relates to the rejection of a claim, put forward by the Confederation of Shipbuilding and Engineering Unions, for an increase of 15 per cent in the wages of adult male workers.

On Tuesday and Wednesday of last week, the engineering industry's case was heard by the court. Mr. Jack Tanner, on behalf of the Confederation of Shipbuilding and Engineering Unions, said that the 15 per cent wage claim was based on the rise in the cost of living since the war ; the increase in productivity in the industry, and on the large and continued increase in profits made in the industry since the war. Mr. Tanner asserted that, although since July, 1939 the minimum rate for a skilled man in the engineering industry had risen by 101 per cent, retail prices—according to the London and Cambridge Economic Bulletin—had risen by 125 per cent. The majority of men in the engineering industry, Mr. Tanner continued, were earning very much less than the average given in the employers' table, and, quoting from figures of annual wages bills, he contended that the annual average wage had increased by no more than about 23 per cent between 1948 and 1952 ; the index of retail prices, Mr. Tanner added, was 26 per cent higher in 1952 than in 1948. He therefore submitted that the real average wage of the workers in 1952 was lower than it was in 1948, despite the very big increase in productivity which took place in the industry in the same period. As the majority of operatives worked no overtime at all in 1952, it seemed probable that their remuneration in 1952 must have been no more than about 20 per cent above 1948. Mr. Tanner then went on to talk about productivity in the engineering industry, and estimated that the increase in output per person employed had been more than 50 per cent since 1946. It was not surprising, therefore, Mr. Tanner argued, that profits in the industry had been going up continuously in the post-war years. It was also clear that in general the proceeds of the vast increase in production had gone into profits, even though successive Chancellors of the Exchequer had taken a share of them in taxation. Mr. Tanner ended his statement by saying that the unions could not believe that an addition to costs such as the claim involved would have the effect of pricing British engineering goods out of international markets. There was no evidence, he said, that British costs were too high to-day, nor that they were responsible for any falling-off in orders for British engineering products. The unions were unable to see how an industry in which there had been such spectacular increases in productivity since the war, in which profits had been rising continuously for many years, and in which massive reserves had been accumulated, should have any difficulty in meeting an addition to its costs of about 2½ per cent.

A statement presenting the views of the Engineering and Allied Employers' National Federation was then made by its director, Mr. B. Macarty. He first of all recalled the increase of 7s. 4d. a week which had been agreed in November, 1952, and said that it was important to consider the changes which had occurred since then in prices and earnings. Comparison had therefore been made between the results of two inquiries carried out amongst member-firms of the Federation in May, 1952, and June, 1953. During that period there was an increase of 4·4 per cent in the index of retail prices. In the same period, for identical hours, the average weekly earnings of adult male workers in the engineering industry showed an increase of 6·56 per cent for timeworkers and 6·31 per cent for payment by result workers. The Federation believed, Mr. Macarty added, that that evidence was sufficient to refute the continuous and mistaken claim that wages had not kept pace with the rise in living costs. Furthermore, the Federation felt that in the engineering industry, where the average pay packet of adult males exceeded the average in industry by about 14s. a week, full regard had been paid to earnings and consequent living standards.

Mr. Macarty then commented on increased productivity in the engineering industry, mentioning the immediate post-war years, when production was replanned, which led up to a progressive period of expansion. During this latter period, he said, owing to the systems of payment in force, earnings had increased with expansion. It had to be remembered, however, that the current output of the industry and that of the last year or two had been considerably in excess of incoming orders. In the year ended May, 1953, Mr. Macarty continued, the volume of orders received declined by about 25 per cent compared with the preceding year, which followed a decline of 8 per cent compared with 1950–51. Export orders alone last year showed a drop of 20 per cent following a decline of 12½ per cent in the preceding year. Greater efforts, keener prices and longer credits were all necessary, Mr. Macarty said, if the position was to remain healthy, for the days were over when prices could be altered with increases in wages and costs of materials. On the matter of profits, Mr. Macarty said that although company reports showed advances in 1950, 1951 and 1952, an ominous trend was apparent in 1953. Profits of 586 companies had fallen from £105·7 million to £100·4 million, although the ordinary dividends paid had increased. But, he pointed out, profits were not only earned for dividends, and a large proportion had to be ploughed back if the industry was to maintain and improve its efficiency. With the need for research and for plant replacement at high cost in an increasingly competitive world, still more money was required and it could only be attracted to industry if there was a reasonable prospect of adequate return in relation to the risk incurred. The Federation's submission was that profits tended to decline and that dividends were very modest in relation to the capital employed. The unions had argued, Mr. Macarty observed, that their claim would increase prices by less than 3½ per cent, but the 1952 wage increase of 7s. 4d. a week had been equivalent to an increase of costs of about 3¼ per cent, and in very few branches of the industry had it been possible to pass that on by raising prices. If the present claim was conceded, the Federation estimated that it would require an increase in prices of two or three times that amount, according to the section of the industry concerned.

On Wednesday of last week, Mr. H. G. Brotherton, president of the Confederation of Shipbuilding and Engineering Unions, replied to points made in the employers' submissions, and Mr. Macarty and Sir Percy Mills replied in greater detail to the arguments put forward by the unions. The chairman of the court, Lord Justice Morris, then intimated that the inquiry into the engineering industry's side of the dispute would be adjourned until January 21st.

On Thursday of last week, the court began its hearing of the shipbuilding wages dispute. Mr. E. J. Hill, secretary of the Boilermakers' Union, presented the case for the shipbuilding unions affiliated to the Confederation of Shipbuilding and Engineering Unions. The arguments which Mr. Hill put to the court were in most respects identical with those submitted on behalf of the engineering unions. He said that the claim for a 15 per cent wage increase was based on two main factors : first, that shipyard workers had suffered a gradual decline in their standard of living in the post-war years, and secondly, that the production records, profits and general prosperity of the shipbuilding industry were such that it was able to make the increase which the unions were asking. Although several wage advances had been made in recent years, Mr. Hill contended, none had been big enough to meet the cost of living. He asserted that the minimum time rate for skilled workers in the shipbuilding industry had risen by 33 per cent between 1947 and now, compared with an increase of 40 per cent in the official index of retail prices. The shipbuilding industry, Mr. Hill continued, had enjoyed remarkable prosperity since 1947, and he claimed that workers in the industry had every right to expect that prosperity to be reflected in the purchasing power of their wages. He agreed that orders for new ships were not now coming in as quickly as they were and that some contracts had been cancelled. Shipping freights, Mr. Hill went on to say, were now at a more reasonable level than in the Korean war boom, and some former competitors who had been put out of business by the second world war were now back again. These, Mr. Hill admitted, might not be very welcome factors at the present, but the unions did not think that they constituted a shipbuilding recession, or even that they gave grounds for anticipating a recession in the near future. What had happened in shipbuilding as in other industries, he claimed, was that there had been a fall from the exceptionally high profits derived in 1951 from the Korean war boom. Later, Mr. Hill told the court that the unions felt that there was sufficient in the industry, without increasing the cost of shipbuilding, to meet the wage claim, if not in full, at least to a large extent of the amount asked.

The evidence for the employers was opened by Sir John Boyd, vice-president of the Shipbuilding Employers' Federation, who emphasised that in the case of exports no additional costs could be borne. The shipbuilding industry, he said, could not afford to go on putting up prices, because other people would not pay them. Foreign competition, Sir John continued, had become pretty acute. In this country the shipbuilding industry was working mainly on a single-shift system, but competing Continental countries, for the most part, were working two shifts, and for each employee the normal working week was forty-eight hours. During 1953, Sir John stated, twenty-eight British shipbuilding firms had booked no orders at all. His information was that completions last year aggregated 1,344,000 tons. That, Sir John commented, constituted a year's work on new ships, yet orders for new ships secured by federated firms last year totalled no more than 519,000 tons. In ship repairing, similar circumstances were showing, and jobs which could have been done in this country had gone to Holland and Germany, and in one instance to Japan. The principal factors, Sir John observed, were time and prices. Britain's workmanship and methods were still the best, but her Continental competitors worked more hours which were paid for at ordinary rates than was the practice in this country. Some of the biggest firms were well booked for two years ahead, without cancellation of orders, but, Sir John said, two-thirds of the British shipbuilding firms, especially those dealing with tankers, required more orders shortly, and if they were not forthcoming there would be a break in the continuity of work which might affect the employment situation. The unions' suggestion that increased wages could come from profits, Sir John claimed, lacked reality. Shipbuilding firms were quite definite that it would be impossible to have an increase in wages without an increase in prices. The needs of modernisation, to keep firms competitive, demanded the use of whatever money there was. The total wages bill for 1952, calculated from reports by federated firms and not including office or salaried staff, amounted to £57,000,000. If, Sir John said, the 15 per cent increase on consolidated time rates was granted to adult male workers only, the wages bill would be increased by 11 per cent. If it was a question of a pay increase for a year, it might possibly be met from reserves, but, Sir John pointed out, it was clearly not possible to pay wages year after year from reserves, for if a recession came, those reserves would be required for carrying on the businesses.

The evidence in connection with shipbuilding and ship repairing wages was concluded on Monday last, and the court adjourned.

SEARCH FOR NATURAL GAS.—We are informed by the Gas Council that the latest development in the search for natural gas began last week in Sussex with the drilling of shallow geological holes near Wych Cross to Ticehurst, to obtain better knowledge of underground contours. The geophysical surveys in Yorkshire and Lincolnshire are making progress and drilling is expected to commence by the end of the month at Cousland, near Edinburgh.

High-Speed Automatic Bending Machine

The prototype of a new high-speed production tube bending machine has been built at the works of Chamberlain Industries, Ltd. Production is going to be in four capacities. This machine is operated by hydraulic power and is arranged for automatic operation at high speed.

A NEW high-speed automatic bending machine for tubes and sections, which was designed and developed in conjunction with Walter P. Hill Inc. of the United States, is now being made by Chamberlain Industries, Ltd., Staffa Works, Leyton, London, E.10. It is proposed to build the machine eventually in four capacities, and we recently had an opportunity to inspect the prototype of the first and smallest model to be completed at Staffa Works. The machine, to be seen in the illustrations on this page, is designed for continuous operation on 1in diameter, 16 gauge copper tubing, and is capable of occasional bends on sections of double the section modulus. In it the tubes are bent cold and unloaded over a conventional former and the bending cycle, once the machine is loaded and started, is completely automatic. The machine is operated by hydraulic power and its former has a particularly smooth, rapid action, which enables the production of high-quality bends free of wrinkles or chatter marks. Hydraulic power for the bender is supplied from a separate power unit stationed a sufficient distance away from the machine to prevent the transmission of vibration and to facilitate maintenance.

The power unit can be seen at the rear of the machine in one of our illustrations, and it consists of a welded steel plate assembly, in the base of which is an oil reservoir of 18 gallons capacity. A heavy steel plate which forms the top of the assembly provides a rigid mounting for a 4 h.p. motor coupled to a vane pump. This pump is designed to deliver 5 gallons of oil a minute at a working pressure of 500 lb per square inch. The bending machine normally uses a much smaller volume of oil than is supplied by the pump, and the oil is passed through a relief valve which by-passes surplus fluid back into the tank. This ensures a constant, even supply of pressure fluid, irrespective of fluctuations in demand whilst the machine is operating.

The bending machine has a rigid main frame of welded steel plate, and arranged along one side in a readily accessible position behind a removable sheet metal cover are all the electrical equipment and hydraulic valves used to control the operation and automatic cycle sequence of the machine.

A hydraulic "actuator" assembly at the front end of the main frame of the machine has a vertical shaft, on the top of which is mounted a swinging head carrying the centre former around which tubes are bent. The arrangement of the actuator can be seen in the illustration and the drawing we reproduce in Fig. 4. The actuator has a body and end covers of aluminium alloy, and its main driving shaft is carried in the end covers in long phosphor-bronze bushes fitted with "O" sealing rings. A single vane is fitted into a deep keyway cut in the shaft, and pressure fluid sweeps this vane round the actuator chamber, which is divided into two compartments by a bulkhead. A sleeve mounted over the main shaft and the inner part of the vane reduces the swept volume of the cylinder and increases the speed of operation by increasing the mean effective radius. Separate pressure fluid inlets and outlets are provided in the body adjacent to the bulkhead.

The body of the actuator is supported on a heavy bracket bolted on the end of the body of the machine. A roller bearing on an extension at the top end of the actuator shaft and a ball bearing on the extended lower end provide the mountings for the swinging head frame. The length of the arc through which the head swings in the bending operation can be set in accordance with the angle it is required to bend the tube. For this purpose an index plate with tapped holes at 15 deg. intervals round its circumference is attached to the lower end of the swinging head frame. A stop on an arm centred on the index plate can quickly be fixed in the required hole and serves automatically to arrest the bending movement by cutting off the supply of pressure fluid to the actuator chamber when it contacts a limit switch on the actuator support bracket. For fine setting purposes, and to obtain angles between the 15 deg. settings, the contact pad of the stop which actuates the switch has means of fine screw adjustment over a short length.

A hydraulic ram mounted on the rear vertical member of the swinging frame has a wedge on its piston which operates a clamp on the top member of the frame. This clamp serves to hold the tube against the centre former during the bending operation.

Another hydraulic ram fixed to the side of the machine, and to be seen on the right in Fig. 3, operates the thrust block of a moving guide which engages the trailing part of a tube to keep it straight during the bending operation. The guide is supported through rollers on the thrust block at its rear so that it can move freely along its axis and provide support for the tube as it advances over the mandrel during bending. A

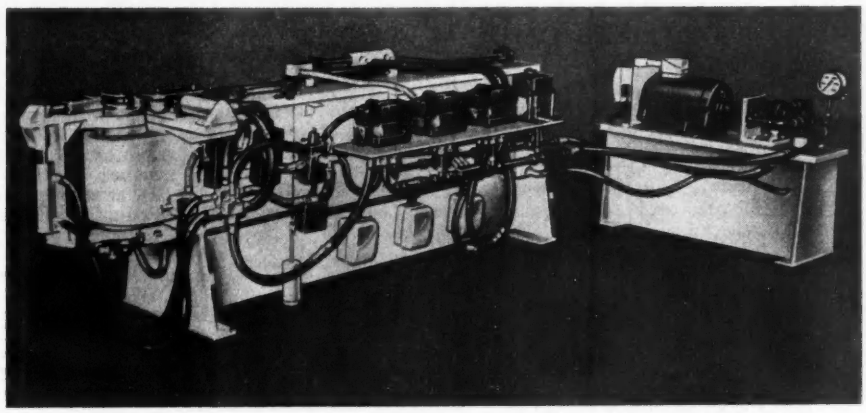


Fig. 2—Rear of Machine with Panel Removed to Show Hydraulic and Electric Control Gear

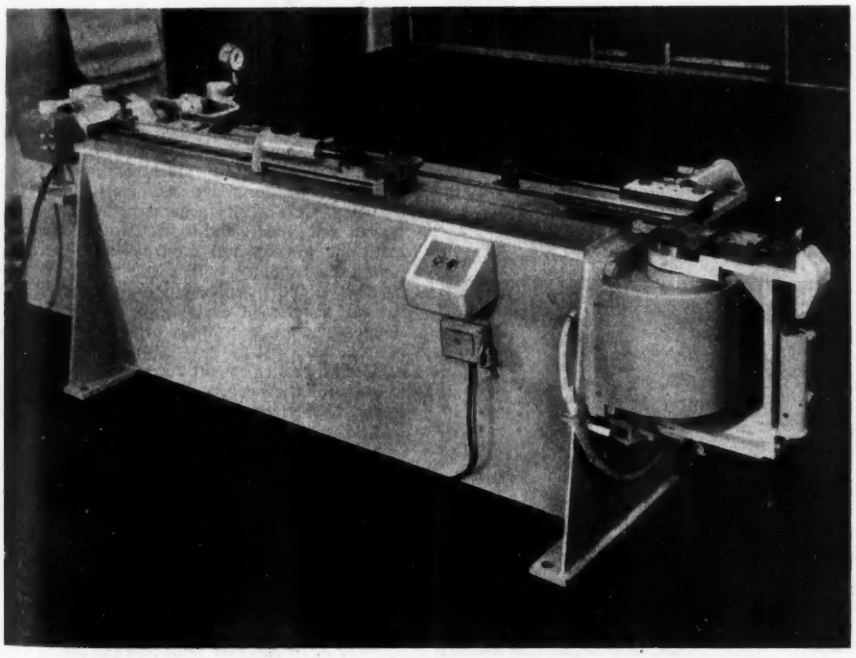


Fig. 1—Front of Tube-Bending Machine, Swinging Head Partly Turned and Tube Clamp Closed

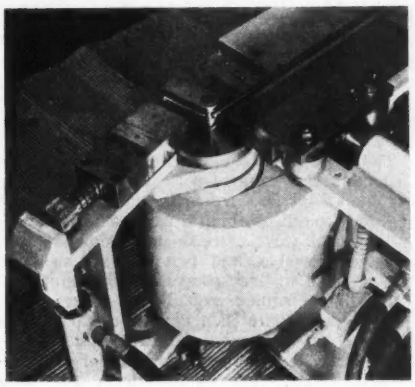


Fig. 3—Actuator with Swinging Head Partly Turned, Clamp Open and Guide Block in Operative Position

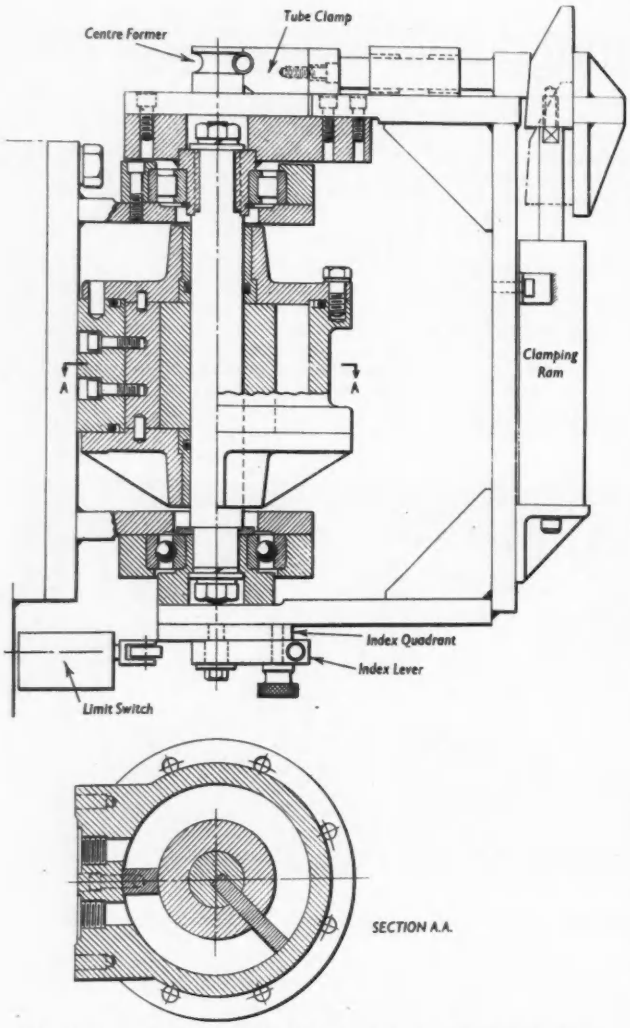


Fig. 4—Arrangement of Bending Machine Actuator and Swinging Head

wire rope attached to the rear end of the guide body passes over a pulley and it has a weight attached to its free end. When the pressure of the thrust block is removed from the moving guide at the end of a bending operation, the weight on the rope comes into effect to retract the guide ready for the next cycle.

A mandrel used to hold the tube in position ready for bending is screwed on a rod supported by a block fixed some way back on the top of the machine. The mandrel rod passes through an ejector plate which is moved forwards by a hydraulic ram at the end of the bending operation and serves to push the bent tube off the centre former. This mandrel, with a tube being drawn off it, can clearly be seen in Fig. 5.

The hydraulic and electric control equipment fitted is all of standard design, and is so arranged that in the event of a breakdown any individual item can be quickly removed and replaced by another out of normal stock. All the hydraulic units fitted on the machine incorporate overload relief valves which provide adequate protection against damage to the mechanism or tools in the event of accidental overloading.

The hydraulic equipment of the machine includes a flow control valve which enables the volume of oil flow from the pump unit to be reduced from 5 to about 2 gallons a minute, an in-line check valve, three solenoid control valves, a sequence valve, and two pressure switches. The nominal working pressure of the equipment is 500 lb per square inch, but pressures up to 1000 lb per square inch can be used, and the machine has been designed with this in view. The electrical equipment consists of a push-button starter, three limit switches and three contactors.

To operate the machine for bending tube the flow control valve is set to give the required speed, and the workpiece is pushed over the mandrel down to the ejector plate. On pressing the starter button, the first solenoid valve is energised, allowing oil to pass into the cylinder operating the guide block, which engages with the workpiece. When the hydraulic pressure has risen to a predetermined figure, the sequence valve operates, and oil is fed to the cylinder operating the clamping die, which moves in to hold the workpiece against the centre former. As the pressure again rises to a predetermined figure the pressure switch is energised, and the second solenoid valve operates, admitting oil to one side of the actuator chamber. The actuator shaft rotates, carrying the swinging head, the centre former and the clamping die with it and drawing the tube over the mandrel. The actuator limit switch is set in a position corresponding with the angle of the bend required and engages the swinging head. When this switch is tripped the second solenoid valve cuts off the oil flow to the actuator and reverses the first solenoid valve, so that the guide block and clamping die are retracted. When both rams are fully retracted and the hydraulic pressure begins to rise, the second pressure switch then allows the third solenoid valve to be energised. Oil is then admitted to the ejector ram and the workpiece is pushed off the mandrel. As the ejector moves forward it strikes the third limit switch, which reverses the third solenoid valve and causes the ejector ram to retract.

Each bending cycle is started by depression of a switch after the tube has been placed on the mandrel and this switch can be suspended from a pendant or placed in any convenient position on the machine.

The machine can be arranged for fully automatic operation when required for bending short lengths of tube. These tubes are loaded in a hopper above the machine and the feed mandrel is mounted on the rod of a long stroke hydraulic ram. At the start of the working cycle the mandrel moves forward to pick up the lower-most tube in the hopper chute and carry it on for normal bending sequence of operations. A separate ejector ram is fitted to remove the bent tube from the swinging head, and when this ram retracts after the ejection stroke the mandrel is automatically retracted and its pick-up cycle restarted.

In the course of a demonstration with the new machine we saw short copper tubes being hand fed, and a bending cycle time of about five seconds was maintained without undue effort on the part of the operator.

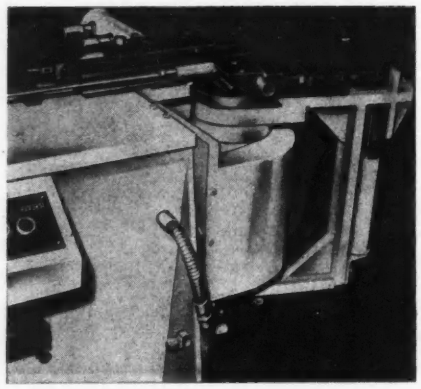


Fig. 5—Tube-Bending Operation in Progress

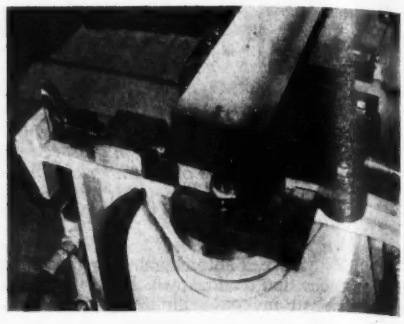


Fig. 6—Completion of a 180 Deg. Tube-Bending Operation with Guide Block Fully Extended

Manufacture of Crankshafts by the Continuous Grain Flow Process

We summarise below a paper with the title "The Manufacture of Crankshafts by the Continuous Grain Flow Process," given by Mr. G. Cleghorn and Mr. I. H. Burnell before the Institute of Marine Engineers on January 12th.

The paper describes a method of manufacturing crankshafts from bar material in a machine adapted for use under a forging press and begins with an historical note concerning the experiments made in France and subsequent developments in England. It is stated that in the C.G.F. process crankshafts are manufactured one throw at a time from bar material which is brought to forging heat and gripped in the machine at the journals and the pin of the crank to be formed. Under the action of the press the outer grips move inwards to upset the material, then the centre grip moves downwards while the outer grips continue to move inward and so the crank-pin is correctly positioned while the upset material forms the webs.

A comparison is made between the usual method and the C.G.F. process, and the advantages of the latter are enumerated and emphasis laid upon the smaller ingot required, the reduction in the amount of machining, and the avoidance of axial unsoundness. Following some notes upon a forging press, the paper gives a description of a C.G.F. machine, which consists essentially of four main castings, together with drawings showing its general arrangement and typical tool holders and tools. Notes explain the hydraulic system and controls and there are piping diagrams for both upper and lower castings, while short paragraphs are concerned with various aspects of installation and operation, touching upon forging, after forging and lubrication.

General particulars are recorded of the special furnace for the process and of the heating time required, then the paper goes on to deal with questions concerning the treatment and straightening to be carried out. The next section of the paper outlines the manufacturing procedure adopted for the forging of two test crankshafts, and gives the analysis of the steel, rolling reduction, heat-treatment after forging, while the results of mechanical tests on a number of test pieces are recorded in a tabular statement. The paper concludes with comments upon current developments and experimental work relating to the process, such as the reduction of friction, the forming of rectangular webs and the possibilities of operating the process without a forging press.

Free-Piston Gas Generators

(By Our American Correspondent)

While for some time now there has been considerable interest in Europe in the development of the free-piston gas generator for feeding gas turbines, this important field of gas turbine technology is only beginning to be explored in the United States. Experience with two installations is recorded here. One produces gas at a pressure of 72·5 lb per square inch gauge and temperature of 1000 deg. Fah. for a 1500 h.p. turbine, and the other has been developed for applications where a higher specific power is desirable. The units in this category produce gas at 90 lb per square inch gauge, 1295 deg. Fah. at the turbine, and have a maximum frequency of 1035 cycles per minute.

IT may be recalled that in the free-piston gas generator cycle, a highly supercharged diesel engine operates solely to supply exhaust gas under pressure to a gas turbine, which furnishes the net output. The generator could be a conventional crankshaft engine, but since no shaft power is taken from it, the free-piston design is preferred. Following interest in the machines of this type built by the Société Industrielle Générale de Mécanique Appliquee (" Sigma ") in France under the Pescara patents, the Bureau of Ships, U.S. Navy, awarded development contracts to two American companies covering the design and construction of free-piston gas generator gas turbines and has now released information relating to their performances. The generator unit developed by the Cooper-Bessemer Corporation, of Mount Vernon, Ohio, works on the principle of outward compression and employs cylinder cooling. It produces gas at a pressure of 72·5 lb per square inch gauge and a temperature of 1000 deg. Fah., which is fed into a 1500 h.p., five-stage reaction gas turbine operating at 14,400 r.p.m. The plant is a heavy-duty unit intended primarily for driving natural gas centrifugal compressors and electric generators.

The generators developed by the Baldwin-Lima-Hamilton Corporation, of Hamilton, Ohio, also make use of outward compression and cylinder cooling. They were designed specifically for lightweight applications and operation at a maximum frequency of 1035 cycles per minute, discharging gas at a pressure of 90 lb per square inch gauge and a temperature of 1295 deg. Fah. to the turbine. These units thus have a higher specific power and were developed particularly for use in naval combat vessels where weight and space requirements are primary considerations.

The first generator constructed by Baldwin-Lima-Hamilton used outward compression with direct and reverse bounce cylinders. The objective in constructing this machine was to obtain the maximum experimental versatility. It was desired to obtain experimental operating characteristics and, in particular, to investigate the question of the maximum speed and pressure at which such a machine could be successfully operated. This so-called Model " A " was operated for 1900 intermittent hours of operation over a 20 lb to 100 lb per square inch gauge pressure range, including one continuous run of 100 hours' duration at 70 lb per square inch and higher. The principal defects encountered were of a structural nature involving the welding of water jackets where they were attached to heavy members. This machine was followed by the slightly larger model " B " in which the synchronisation consisted of a single pair of racks on one side of the machine rather than of double pairs. Model " B " has an 8½in bore power cylinder, a 23in bore compressor cylinder and an 11in full-power stroke. Three units of the model " B " design have been constructed and they have been tested both singly and in tandem operation feeding a gas turbine. Two of these units are now at the Naval Engineering Experimental Station at Annapolis, Maryland. A longitudinal and cross section of the model " B " is shown in the accompanying drawings. Both the models " A " and " B " were designed so that they could be operated at any pressure

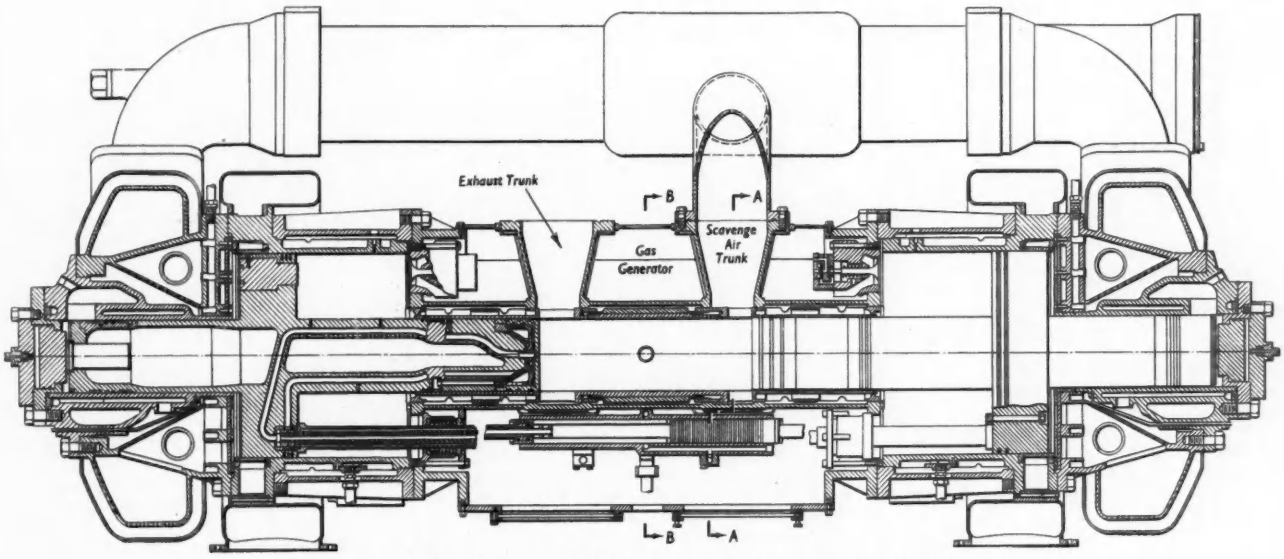


Fig. 1—Longitudinal Section of Baldwin-Lima-Hamilton Free-Piston Gas Generator

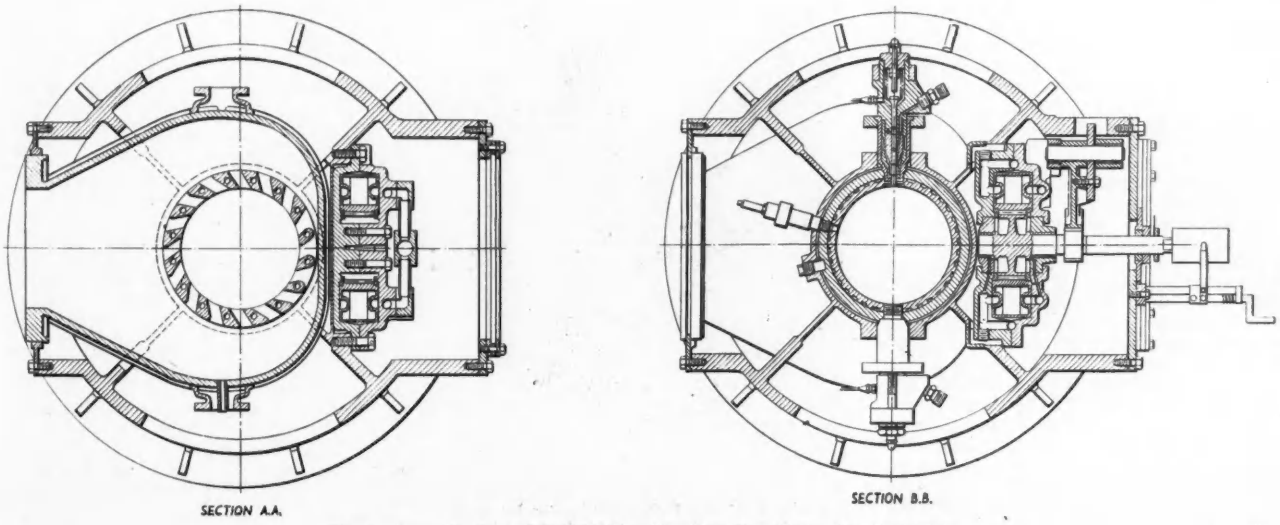


Fig. 2—Cross Sections of Baldwin-Lima-Hamilton Free-Piston Gas Generator

up to 103 lb per square inch gauge, and, if reverse bounce stimulation could be used, for operation at speeds up to 1400 cycles per minute.

In the heads of the reverse bounce spaces are situated four inward opening dump valves, which connect these spaces to atmosphere. They are opened by air pressure and are closed by a spring. The starting sequence is as follows. Air pressure at approximately 20 lb per square inch is supplied to the reverse bounce space. This moves the pistons to the scavenge position. A pressure of approximately 150 lb per square inch is supplied to the direct bounce space. A valve is then rapidly opened which feeds to the dump valves and gives them a rapid opening, and at the same time the air supplied to the reverse bounce and direct bounce is cut off. The pistons are now moved inward to the i.d.c. position, where fuel is injected, driving them outward. At the proper position in the stroke the dump valve air is released and the valves close. The gas generator is now operating under atmospheric conditions. For the model "A," a purely automatic starter with pneumatic elements was constructed. With this the operator had merely to push a single button and the starting cycle was carried out automatically. For the model "B," a simpler design of mechanical starter was used in which the operator carried out the operation by rotating a hand wheel which opened the appropriate valves in successive positions. An important factor in proper starting is that the dump valves are closed in such a position that the proper amount of air is trapped in the reverse bounce space. Four methods have been used to time this dump valve closure. In the automatic starter the closure was effected when the pressure in the direct bounce space had dropped to a fixed level. In the mechanical starter the closure was based on time. The air suddenly supplied to open the dump valves acted on a small weighted piston and set it in motion. After travelling a fixed distance, ports were uncovered which released the air, thus closing the dump valves.

Two of the model "B" generators have been operated feeding a gas turbine. The generators were connected to the turbine by independent gas lines, each of which supplied its own nozzle bank in the turbine. No difficulty of any kind was experienced from the presence of pressure waves in the piping. With one unit operating, the other could be started if the delivery pressure of the first unit did not exceed 30 lb per square inch. Above this pressure, it was necessary to open the by-pass of the second unit in order to start it, but it was not necessary to close the main line valve. It was established that with a synchronising mechanism it is possible to make two or more generators operate in step. The mechanism used consisted of a piston of 2in bore by 2in stroke driving a crank and connecting-rod, a small flywheel, and a rotary valve. This was open for one-half of a revolution and was closed for the other half. The space above the piston was connected by pipe to the reverse bounce space of one unit, and the rotary valve was placed in the feed line to the direct bounce space of the other unit. If this reciprocating pulse motor, which contains no valves of any kind, is set in rotation with a frequency equal to or higher than that of the generator operating it, it will continue to run at the speed of this generator. If the loads on the two generators are not too far from equality, the second generator will then operate in synchronism with the first. While the synchronised generators give a better sounding plant, the synchronisation has no effect on either its output or efficiency.

Recent operating tests of the Baldwin-Lima-Hamilton unit at the U.S. Naval Engineering Experiment Station have indicated a maximum thermal efficiency at the gas generator discharge of 40·3 per cent. Making allowance for the power requirements of the auxiliary plant equipment, the maximum thermal efficiency, on a shaft horsepower basis, was 32·2 per cent.

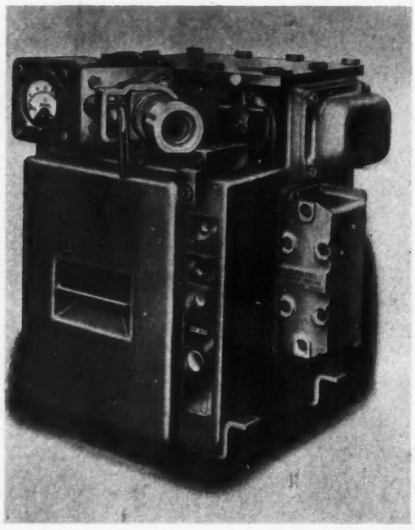
The Cooper-Bessemer Corporation began its laboratory tests in 1952, operating its pilot plant on diesel fuel. The firm's gas generator has a power cylinder bore of about 14in with a compressor cylinder bore of 37in. The scavenging air compression is outward, single-acting, with a net stroke at full load of approximately 18½in at a frequency of 555 cycles per minute. In the Cooper-Bessemer unit the direct bounce piston is outboard of the compressor piston, and there is no necessity for governing the reverse bounce since the pressure in the bounce and compressor rear spaces are automatically controlled. The bounce air supply is taken from the scavenge air, and a single pair of racks connect the two piston assemblies. Three fuel injectors are used in the power cylinder, and the fuel injection system is of the high-pressure storage design with suitable modifications to adapt it to the specific requirements of free-piston machinery. Starting in this design is accomplished by a cycle which automatically places the machine in normal running equilibrium on the first stroke.

The development of the free-piston gas generator-gas turbine combination for electric power generation is aimed initially toward installations of moderate power. Considerable thinking in America to-day is directed toward a 5MW unit consisting of one alternator, one reduction gear and one turbine, with three or four 1750 h.p. gas generators, all considered as one assembly. When fired with "Bunker C" fuel oil or natural gas, such a unit is expected to have a fuel rate at the generator terminals of 9500 B.Th.U. per kilowatt-hour, assuming a reduction gear efficiency of 98 per cent, a turbine efficiency of 85 per cent, and an alternator efficiency of 96 per cent.

Air-Break Mining Contactor Gate-End Box

THE accompanying illustrations show an 80A flameproof mining contactor gate-end box developed and made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17, in accordance with the National Coal Board's standard specification No. P3/1950. This equipment is suitable for the direct-on starting of three-phase squirrel-cage motors up to 650V, 60 h.p. The equipment is housed in a flameproof enclosure certified by Ministry of Fuel and Power Certificate No. FLP 3201. In addition to the usual under-voltage and overload protective devices the contactor unit is provided with a new certified intrinsically safe low-voltage pilot control circuit (Ministry of Fuel and Power Certificate No. T/RC53) and an earth leakage electrical lock-out circuit of intrinsically safe design, which locks out the line contactor until the earth fault is removed. The provision of sequence interlocking, timing device, cable fittings and multi-panel board assembly is optional.

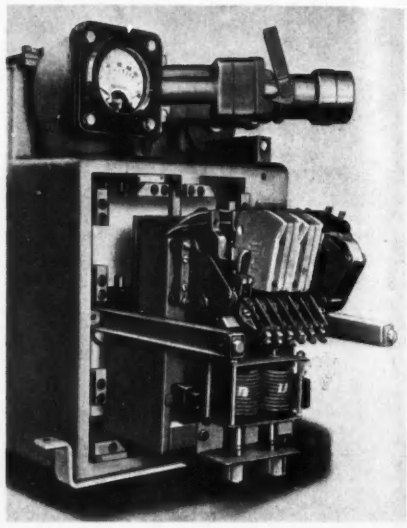
The equipment is enclosed in a welded steel flameproof case divided by a flameproof barrier into two compartments. A top cover closes the upper compartment which contains a set of three-phase, 300A busbars and a triple-pole, on-load, reversing isolator which is electrically interlocked with the contactor.



Mining Contactor Unit, Omitting the Incoming Cable Fitting on the Left of the Busbar Chamber

The lower compartment is closed by a cover with a single securing bolt. Inside the compartment the electrical equipment is carried on a framework which can be withdrawn, for maintenance, on slide rails, as shown in our second illustration. The 80A triple-pole contactor and overload relay coils can be seen in this photograph.

Earth-fault protection is derived from a ring core-balance transformer with a secondary winding connected to an earth-fault relay which can be set to trip when the earth-fault current is 1A or more. The earth-fault relay is energised (to trip the pilot relay and line contactor) by a circuit which includes the earth fault. This circuit constitutes an electrical lock-out which



Mining Contactor Unit with Panel Withdrawn on Slide Rails

can be released only by removal of the earth fault to open the circuit and de-energise the earth-fault relay.

The earth continuity circuit provides for remote control of the equipment and prevents operation if the pilot core, or the earth return between the motor, remote control switch and the unit, is broken or develops a high resistance. It also provides electrical interlocking of the plugs to prevent them from being withdrawn at power voltage. The circuit is supplied with half-wave rectified a.c. and includes a relay with an operating coil having a closed circuit secondary on the same core as the operative winding. In the event of a fault in the pilot circuit, this closed circuit secondary absorbs sufficient of the energy released during the collapse of the magnetic field to reduce any sparking to a level which makes the circuit intrinsically safe. When the mining unit is energised, a current of lower value than the operating current is passed through the pilot relay in the reverse direction, which makes the circuit highly sensitive to changes of resistance in the earth return and pilot core whilst remaining insensitive to voltage changes.

Pilot and earth-core protection is obtained through a half-wave rectifier at the far end of the trailing cable. A short circuit between the pilot core and earth core would cause the half-wave rectifier in the master switch to be shorted out; the alternating current in the pilot relay would then cause it to trip and open the contactor coil circuit.

AGRICULTURAL ENGINEERING SCHOLARSHIP.—The Institution of British Agricultural Engineers announces that the scholarship, which was originally donated in 1952 to the institution by the publishers of *Farm Mechanization*, will again be available for award in October, 1954. The scholarship will be applied for the benefit of a student eligible to undertake the course of study leading to the final examination for the National Diploma in Agricultural Engineering and will be tenable for a year at one of the agricultural colleges approved by the institution. The scholarship is of the value of £100.

1700-Ton Triple-Action Press

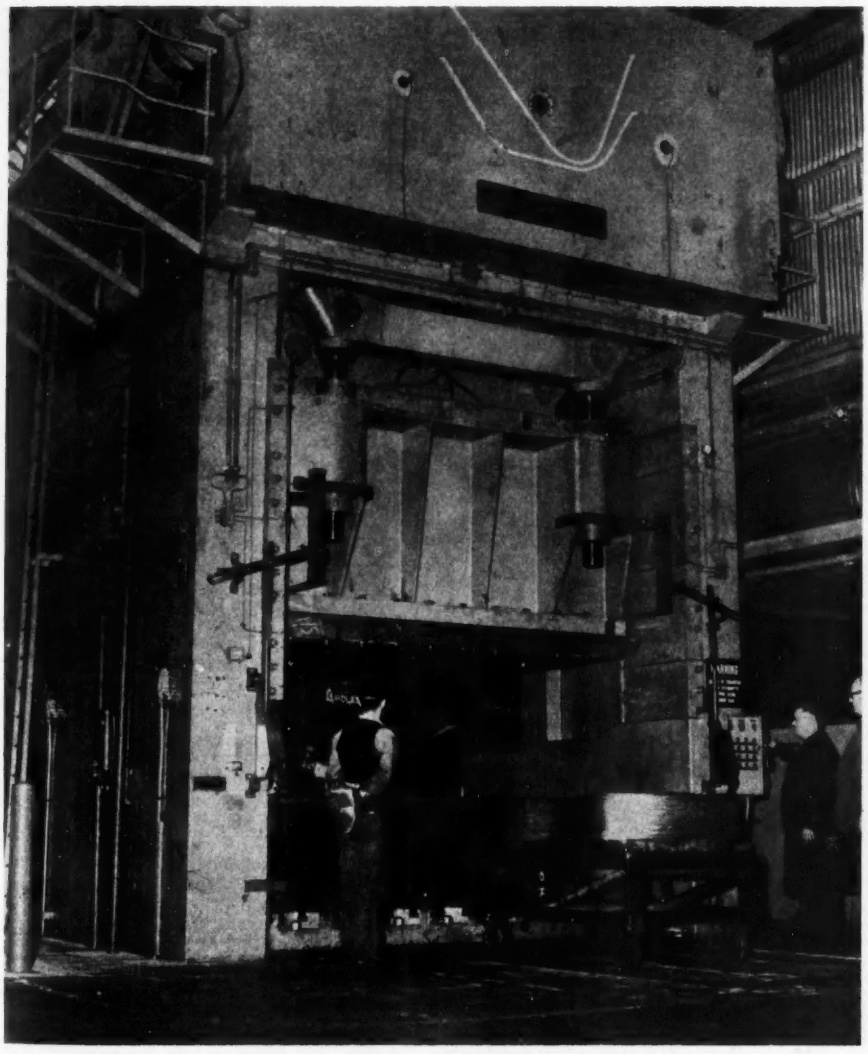
PARTICULARS have been received from the Rockwell Machine Tool Company, Ltd., Welsh Harp, Hendon, London, N.W.2, of a 1700-ton, capacity "British Clearing" triple-action press which has been installed at the works of Vauxhall Motors, Ltd. This machine, built by Vickers-Armstrongs, Ltd., is known as the "Hipodraw" design, and its linkage is so designed that the stroke cycle has a rapid closing speed, reduced drawing speed and quick reversal of both slides. The inner slide and blankholder approach the work at the same speed. When the blankholder reaches its dwell position the inner slide immediately starts the drawing stroke at a greatly reduced speed, followed by the quick reversal of both slides.

The press installed at the Vauxhall works is a triple-action machine and its working range is increased by the fitting of two pneumatic cushions in the lower slide. The capacity of the inner slide is 800 tons, of the blankholder 500 tons, and of the lower slide 400 tons. The bed has an area of 80in by 144in. The inner slide has an effective draw stroke of 13in and the lower slide 10in.

When used in triple-action working the upper mechanism of the press completes the draw stroke, and the automatic control cuts out the upper action causing the slide to dwell at the bottom of stroke, whilst the lower action, which is automatically cut in, carries out its required operation on completion of which the press automatically returns to the rest position in preparation for the next stroke. The lower action can be cut out for the press to be used as a double-action machine with or without the use of cushions. In double-action operation, the inner slide dwell at the bottom of the stroke does not occur.

Both upper and lower action mechanisms are fitted with pneumatically operated clutches and brakes. The drive of the upper action is provided by a 125 h.p. motor and that of the lower action by 40 h.p. motor. Both motors are of high-torque, high-slip design and power is transmitted by means of vee belts to the flywheels. Means of upper and lower slide power adjustment is provided for by 7½ h.p. motors. Various preselected automatic control cycles are available.

For the installation of the press, which weighs some 318 tons, 9000 cubic feet of soil were excavated for the concrete-lined foundation pit, and 30ft piles were sunk below the foundations.



1700-Ton Capacity Triple-Action Press

Petrol Distribution Stations

ONE of the phases which fuel oil and petrol have to go through in their passage from the oilfields to the consumer is that of storage at convenient centres from whence they can be drawn out and conveyed to the fuel pumps, filling stations and private users' tanks by road. The Vacuum Oil Company has recently constructed a number of such stations (for which Messrs. Maunsell, Posford and Pavry acted as consultants) some of which, as in the case of the seaside Sunderland depot, are supplied direct through pipe from the wharves and others such as the inland depot at Coventry, have to be refuelled by road. On arrival at the depot the oil is run into 12,000-gallon storage tanks.

These storage tanks are at ground level within bund walls, the petrol tanks within a separate compound from those containing diesel fuel. Each bunded area is separately drained, a valve pit and interceptor being provided, so that spillage of fuel can be pumped off for subsequent reclamation, at the same time preventing any petrol or oil from being carried over into the normal sewage disposal system. Similar arrangements are made where leakage might occur on the general site drainage. Service vehicles, for transporting fuel from the depots to the service stations, draw up under the canopy of the loading island where the driver himself controls the filling of each of the four 600-gallon compartments of the tank with whatever fuels are required. The loading island is laid out with three double hose outlets—one for each fuel—and with remote control push button switches for operating the pump motors. These motors, with the pumps, deaerators, and a comprehensive system of valving, are mounted on a drained concrete slab annexed to the storage compound.

This pumping layout is a sufficiently important engineering contribution to the marketing of petrol and fuel oil to make these new fuel oil depots unique in the petroleum industry outside America. Because of it, the storage tanks can be put at ground level, thus saving expensive supporting structures; by it a 3600-gallon tanker can be emptied in less than fifteen minutes and the time of turn-round of a service vehicle can be reduced to about one-quarter of the time taken under conventional systems; further, by a simple change involving only two short lengths of pipe at each pump, it is possible, if required in the future, to change the existing pumps for others having twice the throughput.

Speed of operation is not the sole improvement, however, as improvements have also been made in quantity control. On the loading island meters are installed in the hose lines in positions which make for easy reading by the driver when standing on top of the vehicle, so that an accurately measured quantity of each fuel is put into the lorry. Similar meters installed on the lorries themselves provide the same accuracy when unloading into the tanks at the service stations.

In all installations involving petroleum storage, special precautions must be taken to guard against any possibility of fire, and where fire does break out, then special methods for fighting it are employed. Static electricity forms a considerable source of danger which can only be mitigated by earthing each tank, pipe run, pump or other piece of plant. Also, the whole of the electrical system must be built of flameproof equipment. The remote control of the pump motors from the loading island constitutes an additional safeguard to the operators. At the coastal terminal, where individual storage tanks have capacities of up to 250,000 gallons, fire-fighting equipment is permanently installed, hose connections being provided at a suitable central point from which foam lines are run in pairs into the top of each tank.

Lighting of the site is provided by floodlights placed 24ft above the ground, careful attention being paid to obtaining even illumination over the whole area. Additional light is provided beneath the canopy of the loading island, and each meter has a special hooded light to enable the figures to be read quickly and easily.

Nickel for Electronic Valves

Two new grades of nickel suitable for the manufacture of electrodes and other parts of valves have recently been introduced by Henry Wiggin and Co., Ltd., Birmingham. The compositions of the new materials, "HPA" and "HPB" nickel are tabulated herewith.

Composition of "H.P.A." and "H.P.B." Nickel

	"H.P.A." per cent	"H.P.B." Per cent
C	0·10 max.	0·10 max.
Cu	0·04 max.	0·04 max.
Fe	0·05 max.	0·05–1·0
Mn	0·02 max.	0·10 max.
Mg	0·01 max.	0·01 max.
Si	0·03 max.	0·15–0·25
Al	0·01–0·05	0·02 max.
S	0·005 max.	0·005 max.
Ni and Co	99·5 min.	99·5 min.

"H.P.A." nickel is a very pure grade of nickel with a minimum content of 99·5 per cent, available in the form of strip, tape and wire. It is specially recommended for com-

ponents of valves operating at high temperatures in applications where the evaporation of volatile elements such as magnesium cannot be tolerated. It is also useful for cathodes of valves which must have a very long life, while delivering only low emission current.

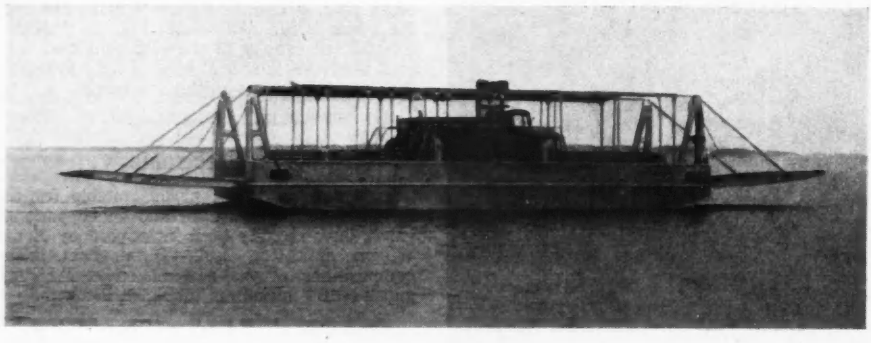
" H.P.B." nickel is intended primarily as a material for cathodes in those instances where the sublimation of magnesium cannot be tolerated because of very small inter-electrode distances, or where the operating temperature of the cathode is higher than usual and leads to excessive evaporation of magnesium from the cathode. The high silicon content of " H.P.B." nickel ensures ready activation and good emission. It is stated, however, that care must be exercised in the running of valves with " H.P.B." nickel since the high silicon content can result in the build-up of high interface impedances between the cathode sleeve and the coating material under certain conditions.

Double-Ended Ferry

A SMALL double-ended ferry, built of aluminium alloy, has been supplied recently to the order of the Crown Agents for the Colonies for service in Sarawak. The craft, which was designed by the Fairmile Construction Company, Ltd., and built at Freezer's Yard, Hayling Island, is intended to provide a self-contained transport for a lorry or two cars, and thirty passengers across a shallow river about 100 yards wide. The use of light alloy has reduced the weight of the ferry and when loaded with 16 tons the draught is 20½in. Over the ramps the ferry measures 75ft 6in, while the main hull has a length of 45ft by 16ft beam by 3ft 9in deep, with bridge casing to port and starboard raised 1ft 9in above the car deck. Propulsion is by Hotchkiss internal cones, which give the ferry a speed of 6 knots on trials and ensure that the bottom is free from stern gear.

Steering is effected by means of four interlocked galvanised steel rudders, mounted in pairs at each end of the vessel, and operated by rods and cams through 10 to 1 reduction gears, fitted fore and aft, from a single steering pedestal located amidships. Each rudder has an immersed area of about 2½ square feet and an angle of helm of 35 deg. to port and starboard, and the four rudders give the ferry a turning circle of about two lengths diameter.

The ramps, which are fitted with a double row of 2½in by ¾in teak tread strips, are arranged to balance each other partially and are raised and lowered by a 1½in flexible steel wire rope, lead over large diameter sheaves on the top of the ramp gallows, and operated by a geared hand winch mounted amidships. The ferry takes the ground on concrete shore ramps having a slope of 1 in 7, and when being loaded rests on a pair of galvanised steel skegs, arranged



Double-Ended Ferry for Sarawak

inboard of the rudders, and designed to take the full weight of the ferry and her cargo. Renewable teak shoes are fitted to the skegs.

Sparred hardwood seats are provided for the passengers, who are protected by awnings of 14 S.W.G. aluminium sheet. Each of the three hull compartments is fitted with a 3in hand-operated bilge pump and other equipment includes a " C.Q.R." anchor and a small hand-operated anchor winch. The aluminium alloys used were supplied by Birmabright, Ltd., and the Metals Division of Imperial Chemical Industries, Ltd. The side and bottom plating is 3/16in and ¼in thick respectively, and the deck plating of 3/16in tread plates. For the bottom frames 3in by 2in by ¼in ordinary angle was used and 2in by 2in by 3/16in ordinary angle for the side framing, both being 18in apart. The main deck beams are 5¾in by 2½in by ¾in by ¼in Z bars, while the keelsons are 3in by 3in by ¼in T bars.

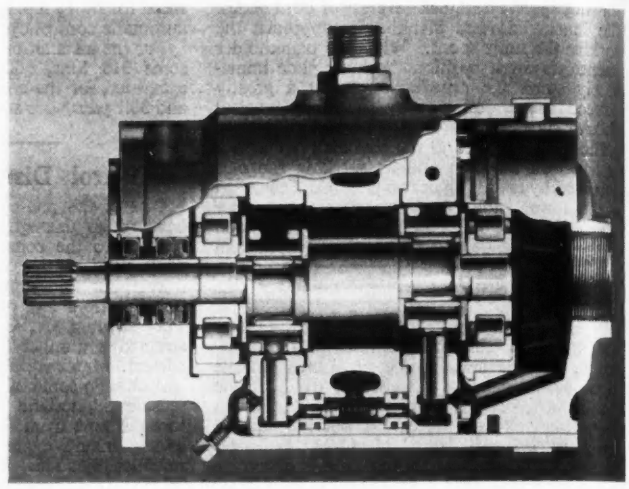
Power for propulsion is provided by a Perkins Mark P.6M. six-cylinder in-line diesel engine having a bore and stroke of 3½in by 5in respectively and an output of 43/65 b.h.p. at 1250/2000 r.p.m. The engine, which is rubber mounted, drives by means of a universally jointed shatf, a Lohmann twin-disc oil-operated reverse gear-box which is capable of moving the vessel continuously in either direction. The gearbox is coupled to a Hotchkiss 10 to 1 worm reduction gear driving through transverse shafting, a pair of 48in Hotchkiss cones mounted to port and starboard. Arrangements are made to pump out the fore and aft compartments by the port side cone, while the starboard cone is connected to the engine-room bilge suction.

High-Pressure Hydraulic Pump

WITH the increased size of aircraft operating at the present time and the possible increases in size contemplated in future designs, it was anticipated that the demand for hydraulic power would become greater. To meet this demand the Aircraft Division of the Lockheed Hydraulic Brake Company, Ltd., began to design a hydraulic pump of much larger power than the current Mark 7, which has a delivery of 2·5 gallons per minute with a working pressure of 3000 lb per square inch. As a result, a new engine-driven hydraulic pump has been developed which has a rated maximum working pressure of 3000 lb per square inch, coupled with a rated minimum delivery of 5·12 gallons per minute.

The new unit, of which we show a sectioned view, thus has twice the output of the older Mark 7 pump and incorporates many of the design components which have proved successful in the earlier model. The latest pump can be described as a double-banked, Mark 7 unit, which is a seven-cylinder radial plunger pump actuated by an eccentric shaft integral with the driving shaft. There are two radial banks, each of seven cylinders, actuated by a two-throw eccentric shaft in the new model, and the large number of cylinders ensures that the hydraulic system is free from the pressure pulses which occur in pumps with a comparatively small number of cylinders.

In designing the Mark 8 pump no attempt was made to give it greater versatility than its predecessor and, like the Mark 7, it continues to be a straightforward pumping unit with on



Section Through High-Pressure Hydraulic Pump

off-loading devices or other extras which would decrease efficiency or destroy the ideal of simplicity. As with the Mark 7, the larger pump continues to be a cool running unit and even under maximum load does not generate excessive heat.

The inlet porting is automatic and a groove cut in each cylinder is so positioned that it is partly uncovered just before the plunger reaches the bottom of its stroke. This inlet port is covered by the plunger on the compression stroke and the trapped fluid is forced through the passage which leads from the cylinder top past a delivery valve into an annular passage in the high-pressure cover, leading to the outlet connection. Modifications have been incorporated in the inlet passages of the new pump and the drive shaft strengthened to transmit the higher powers demanded by the larger output.

In the hydraulic systems associated with the Mark 8 pump, " Non-flam " and other water-based fluids can be employed and the shaft seals fitted are resistant to the new synthetic turbine oils. As already mentioned, the maximum working pressure is 3000 lb per square inch and the rated minimum delivery 5·12 gallons per minute, while the rated maximum cruising speed is 3300 r.p.m. At this speed and pressure the horsepower is approximately 12·9 and the overspeed at the maximum pressure is 4000 r.p.m.

CONCRETE FOR ZEBRA CROSSINGS.—Experimental zebra crossings laid by the Road Research Laboratory indicate that concrete markings are likely to give many years of service. To provide good contrast at night, particularly on roads carrying heavy traffic, the white stripes of each zebra crossing are given a smooth finish and the black stripes a rough finish. Nine crossings, with cast-in-situ white stripes and mastic asphalt black stripes, have been laid in streets of the Metropolitan Borough of Stepney, which carry a great deal of traffic. One of the crossings has had some 14,000 tons of turning traffic over it every day for eighteen months, it is stated, and looks little different from the day it was laid. These concrete stripes were laid either 1in or 2in thick on a concrete base of 7in or 9in. A white aggregate is essential for the stripes, because it will become exposed with wear ; calcined flint was found to be satisfactory and was used in all the experimental crossings. The addition of 5 per cent of titanium oxide was found to make the concrete whiter and give a better contrast with the black stripes. Precoated chippings spread thickly were rolled into the asphalt to provide a rough-textured surface. Eight other crossings have been laid in which the black and white stripes are formed with precast concrete blocks. Three have been in service for five, four and two years respectively, and all of them have behaved well. They use blocks 4in thick and 1ft square. More recent crossings using blocks 3in and 2in thick have been laid in Stepney. The blocks are made of coloured concrete ¼in to 1in thick, backed with high-quality ordinary concrete.

Industrial and Labour Notes

Electrical Contracting Industry's Dispute

There was little change throughout last week in the circumstances attaching to the dispute in the electrical contracting industry. The "guerilla" strikes, organised by the Electrical Trades Union, were resumed in various parts of the country, though the National Federated Electrical Association did not take any action in withholding work from those who participated in these one-day stoppages. Last Monday, there was what the Electrical Trades Union called a nation-wide stoppage of work in which it has been reported 30,000 workers participated. On the following day, it was stated that, following the advice of the National Federated Electrical Association, firms belonging to the Association refused work to those who had taken part in the strike. Subsequently, the Electrical Trades Union announced that its "guerilla" action would be intensified. When Parliament reassembled on Tuesday, the Minister of Labour, Sir Walter Monckton, made a statement about the dispute. He said that officers of the Ministry had had discussions with both parties but no basis for a settlement could be found. As matters stood at present, he had not thought it desirable to refer the dispute to a tribunal. There were indications, the Minister continued, that some further intensification of the dispute was under consideration. The services of Ministry of Labour officers were still available to the parties.

Britain's Overseas Trade

The Board of Trade has stated that exports of United Kingdom goods in December have been valued provisionally at £224·6 million, which was £15,000,000 below the total reached in November. Both months had twenty-five working days, but November, of course, was not affected by public holidays. In December, 1952, exports were valued at £207·5 million. Imports in December last have been valued at £281·5 million.

The monthly average of United Kingdom exports in the fourth quarter of last year, at £230·6 million, was higher than at any time since the first quarter of 1952. Imports in the fourth quarter of 1953 averaged £276·8 million a month, which was slightly above the third quarter's level, but was 2 per cent below the monthly rate in the first half of the year. Provisionally, the total value of United Kingdom exports for the whole of 1953 has been put at £2,582 million, which is just about the same as the total for 1952. At lower average values, however, last year's total indicates an increase in volume compared with 1952. Imports last year totalled £3,347 million, which was 4 per cent less than in 1952 and 14 per cent below the 1951 figure, but 28 per cent more than in 1950 when imports were valued at £2,608 million. Re-exports last year, valued at £105 million, were 27 per cent lower than in 1952, and the excess of imports over exports and re-exports in 1953, estimated at £660 million, was 12 per cent less than in the preceding year.

Export Problems

Sir Thomas D. Barlow, chairman of District Bank, Ltd., has circulated, with the annual report and accounts, a statement in which he comments upon several economic and industrial matters. In the course of the statement, Sir Thomas points out that trading conditions are in many ways exceedingly difficult and subject to incalculable changes. A year ago, he says, monetary and investment policy was framed to restrain home demand for capital goods, for which there was strong overseas inquiry, and not to depress the internal trade for consumer goods for which overseas demand had declined. With tax concessions modifying that policy to-day, and with greater external demand for consumer goods, it may well be difficult for exporters to accommodate themselves to these changes, to say nothing of numerous other complications.

Of recent months, the statement continues, there has been some lack of sterling and, as at the same time more dollars have been available, there has been a growing tendency for certain countries to buy from the U.S.A. rather than from this country. It is also inevitable that there should be some slackening of demand as we move into a buyer's market because customers tend to delay their orders in the expectation of lower prices. Furthermore, Sir Thomas observes, various incentive schemes by which some countries seek to increase their sales abroad hamper our exporters, while barter agreements and political influences impede the normal trend of international trade.

Allowing for these conflicting circumstances, the statement says, it is not surprising, though extremely disconcerting, that, judged by volume, no major group of this country's exports appears to be really strong enough to hold its own against external pressures. Textiles and certain other consumer goods, which were the first to wilt under the difficult trading conditions of 1952, have subsequently made some recovery. On the other hand, metal and engineering products, which gave way more slowly, have declined steadily and, despite a recent improvement, still fail to make satisfactory headway even with the notable support afforded by Britain's newest export, aircraft. Such contrasting experience, Sir Thomas suggests, emphasises the wisdom of not depending too much on one group of exports alone. Plainly, he thinks, the lesson to be drawn is that the broad divisions of our exports—consumer and capital goods—do not experience the same vicissitudes at the same time and that, if this country is to aim at overall stability in good times and bad, the importance of both sections must be recognised. Moreover, the statement adds, the economies of many countries are still so artificially supported by rearmament, or by intensive nationalism fostered by prolonged inflation, that the ups and downs of trade are not likely to diminish in any foreseeable time.

Importance of Productivity

In another part of Sir Thomas Barlow's statement as chairman of District Bank, Ltd., which is referred to in the preceding note, the importance of productivity is emphasised. The statement says that it is impossible to overestimate the importance of efficiency at the present juncture when, in the interests of the nation at large, production has to cope with an active domestic trade and make a bid for exports at one and the same time, a time, incidentally, when not a day passes without reports of mounting competition in world markets.

The statement goes on to say that, despite what has been done to increase efficiency, it seems scarcely possible that exports will not fall far short of what is urgently required if wages are allowed to raise costs when many other countries are effectively containing their inflation. In addition, Sir Thomas observes, this country is considerably hampered—as responsible quarters recognise only too well—by a serious lack of capital for industrial development. That, Sir Thomas admits, may seem a tedious repetition of the obvious, but so inadequate has been the flow of capital over recent years that, for industry as a whole, it has been practicable to do far too little beyond offsetting wear and tear of equipment.

Cheaper exports in quantity, the statement continues, cannot therefore be expected immediately by means of increased mechanical resources, and if they are to be produced—as indeed they must—it can only be by a much better use of existing capital equipment. The key to an increasing output of exports at the right price, Sir Thomas urges, is much greater productivity, which can only be achieved by the unflagging and co-ordinated effort of management and men.

Censuses of Production and Distribution

The Association of British Chambers of Commerce has submitted, to a Board of Trade committee, a memorandum advising the Government to abandon the taking of censuses of production and distribution. The Association's view is that close co-operation between the Government and national and trade organisations could provide the Government with such information as is necessary for forward economic planning. That information, the memorandum asserts, could be compiled with far greater speed and accuracy, and at less cost, than is involved in the present rather cumbersome censuses of production and distribution. To a limited extent, the Association claims, Government servants are duplicating, and doing with less efficiency, a great deal of work which industry and commerce already carry out through the medium of trade organisations.

As an example of the time taken up in providing material for the census of production, the memorandum quotes the experience of a Scottish engineering company employing 370 operatives. The analysis of materials and fuel purchased related to 7500 invoices containing 20,000 items and involved sixty man-hours of work; while that relating to work given out involved 4700 purchase orders, taking up twenty man-hours. An analysis of transport costs took fifteen man-hours to extract and the information required about canteens took eight man-hours to collect. The company thus found that the entire census involved 120 man-hours.

The memorandum expresses the Association's doubt about the reliability and value of the data collected by the censuses of production and distribution. It suggests that, as the information collected is in a completely different form from that upon which industry and commerce base their decisions and conclusions, the Government's forward planning may not correspond with the real interests and needs of trade and industry.

Commonwealth Development

Last week-end the Commonwealth Finance Ministers issued a communiqué, at the conclusion of their conference in Sydney. In that document, the great natural, human and industrial resources of the Commonwealth are emphasised, and attention is drawn to the urgent need for developing those resources. The aim of all sterling area Commonwealth countries, it is stated, is to concentrate on the development of those resources, which directly or indirectly contribute on an economic basis towards improving the balance of payments of the sterling area.

The communiqué goes on to make reference to "the immense variety and intensity of the efforts which are being made to turn to productive use the many resources both large and small of Commonwealth countries." Giving some examples, it mentions the development of food production, which has been intensified throughout the Commonwealth, and which has involved irrigation and other schemes for bringing more land under cultivation, technical improvements, mechanisation and training. Mention is also made of the continued development of mineral resources, and of the fact that in a number of countries the search for oil and the development of oil and production of natural gas are in progress. The communiqué then refers to the important place being accorded in Commonwealth countries to the development of heavy industries, and in particular to the expansion of iron and steel and aluminium production which is proceeding in a number of countries. Efforts to improve transport facilities are continuing, and there are also substantial programmes for increasing both thermal and hydro-electric generating capacity.

The communiqué says that the conference of Finance Ministers reviewed the factors affecting the scope and pace of development. It was agreed that supplies of goods for development have much improved, but it also was made clear that, in most cases, "finance is still the major factor limiting development." There is evidence, the communiqué adds, that development everywhere has gone ahead more smoothly and economically as inflation has been checked and excessive competition for resources has been materially lessened. This makes it clear that sound internal policies are just as important to economic growth as they are to a healthy balance of payments.

Notes and Memoranda

Rail and Road

DIESEL-ELECTRIC LOCOMOTIVES FOR AUSTRALIA.—The first of forty-eight 1105 h.p. class "X" diesel-electric locomotives for the Western Australian Government Railways has been dispatched from this country. The electrical equipment of these locomotives is being made at the Metropolitan-Vickers works at Sheffield and Trafford Park and the mechanical parts are being made and the locomotives erected by Metropolitan-Vickers, and Beyer, Peacock, Ltd., at Stockton-on-Tees. We are informed that these locomotives form the largest diesel-electric traction order ever placed with a British firm, the order being valued at £2,250,000 sterling. Each locomotive has a two stroke Crossley diesel engine, which, under the operating climatic conditions and the specified requirements, delivers 1105 h.p. and gives a maximum service speed of 55 m.p.h. With a designed axle load of 10 tons, the locomotives weigh 77½ tons in full working order.

Air and Water

LAUNCH OF "SAXONIA."—The first of three liners, each of 22,000 tons gross, which have been ordered by the Cunard Steam Ship Company, Ltd., for its service to Canada, will be launched from the yard of John Brown and Co., Ltd., on February 17th, and the ship will be named "Saxonia" by Lady Churchill.

INSTITUTE OF MARINE ENGINEERS.—Mr. Thomas McLaren, chief superintendent engineer of the Cunard Steam Ship Company, Ltd., has been elected chairman of the Merseyside and North-Western section of the Institute of Marine Engineers in succession to Mr. G. Pickering, principal surveyor at Liverpool for Lloyd's Register of Shipping.

Miscellanea

MR. H. R. BACKHOUSE.—We regret to record the death of Mr. H. R. Backhouse, which occurred at Leicester on January 5th. Mr. Backhouse, who was fifty-nine, was chairman and managing director of Mellor Bromley and Co., Ltd., which firm he joined in 1928. Prior to that he had served on the staff of B.S.A., Ltd.

DOUGLAS HAY MEDAL AWARD.—The Institution of Mining Engineers states that the fourth award of the Douglas Hay Medal has been made to Professor D. W. Phillips, of the New South Wales University of Technology. Professor Phillips receives the award in recognition of his outstanding contributions towards the solution of the problems of strata control, and for his valuable work on the physical properties of coal-measure strata.

ELECTRICAL RESEARCH ASSOCIATION.—The Electrical Research Association has announced the retirement of Dr. W. B. Whitney, M.I.C.E., M.I.E.E., from the position of assistant director. He is continuing his connection with the E.R.A. in a part-time capacity. Dr. Whitney joined the staff of the Association in 1920, and was responsible for the development of the switch and control gear department, of which he has had full charge. In addition, he has been assistant director since 1950.

LEATHER "VEE" BELTING.—A new design of adjustable leather "vee" belting is now being made by Carol Beltings, Ltd., 12, Grays Inn Road, London, W.C.1, under the trade name, "Adjusticon." This multi-ply leather belting is reinforced by evenly spaced tubular metal eyelets and by means of these eyelets and a special "U"-shaped fastener belts can be easily adjusted for length. The fastener is held in place by a spring steel plate and is relatively short so that it does not impair the flexibility of the belt on small diameter pulleys. The new belting is supplied in standard sizes and in lengths of 25ft, 50ft or 100ft, which can be cut up to lengths for the ends to be joined together as required.

MINING ENGINEERING SCHOLARSHIPS.—The National Coal Board is offering 100 university scholarships in mining engineering and allied subjects. These scholarships are available to boys who have reached a high standard in the General Certificate of Education or the Scottish Leaving Certificate, young men already in the industry who have university entrance qualifications, and to certain graduates who wish to extend their qualifications for posts of high technical responsibility in mining. The scholarships, which are without a means test, cover the whole cost of education and carry maintenance allowances which may amount to more than £300 a year, with extra allowances for married men. Application forms, which must be returned by April 30th, can be obtained from the National Coal Board (Education Branch), Hobart House, London, S.W.1.

FIRE RESEARCH EXHIBITION.—During the period February 10th to 26th an exhibition dealing with the work of the Fire Research Station, Elstree, will be held at the Royal Institute of British Architects, 66, Portland Place, W.1. One of the exhibits in the exhibition will deal with the manner in which every year some 80,000 reports on fires are classified and analysed. Other subjects covered by the exhibition will include the testing of wood, wallboards, textiles and other materials, and will illustrate how tests of the ignitability of these materials make it possible to decide their safe distances from hot sources. The exhibition will show how models are used for testing the speed of flame-spread on wall surfaces of various materials, where hitherto full-scale destructive tests were necessary. Other exhibits illustrate the work done at the Station on the fire resistance of walls, floors, columns and beams of various forms, where components are furnace tested to destruction. Particular reference is made to the valuable work which has been done recently on the fire resistance of prestressed concrete beams and columns. The exhibition will also illustrate the behaviour of smouldering materials in causing fires and show work on the problems of fire fighting. A section dealing with burning liquids will illustrate the use of water sprays with carefully controlled drop sizes and the use of foam solutions for smothering fires in highly inflammable liquids. The exhibition will be on view until 7 p.m. daily and on Saturdays, 5 p.m. Admission is free.

FILMS FOR INDUSTRY.—We are informed by the Board of Trade that a new Central Film Library catalogue "Films for Industry" has been published and can be obtained from Central Film Library, Government Building, Bromyard Avenue, Acton, London, W.3; Scottish Central Film Library, 16–17, Woodside Terrace, Charing Cross, Glasgow, C.3, and Central Film Library of Wales, 42, Park Place, Cardiff, price 1s. 6d., post free. The catalogue contains particulars of 273 films which are available for use on 16mm sound projectors and cover a wide variety of subjects ranging from building to workshop practice.

FILM ON THE METALOCK PROCESS.—We recently attended the first showing of a new film which deals with the cold repair process for fractured castings, forgings and other machine parts and the service operated by Metalock (Britain), Ltd., Grand Buildings, Trafalgar Square, London, W.C.2. The process was described in our issue of October 24, 1947, and, as is now generally known, consists of driving a number of specially shaped key elements into the fractured part across the crack and then sealing them by cold working to hold the parts rigidly together. The film describes graphically a number of the methods used for different classes of fracture and shows a selection of the heavy plant and machines which have been successfully repaired and restored to service within very short times.

ESTIMATING FOR BLACKSMITHS.—A useful little book entitled *Elementary Principles in Estimating for Rural Blacksmiths and Agricultural Engineers* has just been published by the Rural Industries Bureau, 35, Camp Road, Wimbledon, S.W.19. There are, of course, many books on estimating, but there are few, if any, which cover completely the varied work of the country blacksmith and agricultural engineer. This book will help to make good that deficiency. It discusses such matters as the essential factors that must be known before an estimate can be prepared, deals with quantities, and gives some examples of estimates for different jobs. The latter part of the book gives a selection of tables which will be of considerable assistance in many a rural workshop. The price of the book is 3s. 6d.

CAST IRON PIPES.—The Minister of Housing and Local Government has informed local authorities about changes in ordering cast iron pipes. Up till now authorities have been asked, when ordering pipes, to attach a certificate that the scheme to which the order relates has been authorised by the Ministry; this has applied to all orders over a fixed amount, at present £500, except orders for repairs and maintenance. The Minister says that he has now been informed by the makers that the supply position has improved sufficiently to make it possible to dispense with these certificates. This should help both the authorities and the makers provided there is no excessive ordering as a result. On their part the makers have assured the Minister that they will give priority to orders of pipes for any scheme specially notified to them by his department as urgent.

INSTITUTION OF MINING AND METALLURGY.—A limited number of travelling Fellowships is to be offered by the Institution of Mining and Metallurgy to members of the teaching staffs of universities and approved schools of mines and metallurgy in the United Kingdom, to enable them to visit important mining and metallurgical centres and research establishments in the 1954 long vacation. Applicants should be thirty years of age or over, and should be engaged in the teaching of mining engineering, extraction metallurgy, or economic geology. The tenure and value of each Fellowship will be decided according to individual requirements, but in general will not exceed three months and the value will not be greater than £500. The award is intended to meet the travelling expenses of the Fellow. Forms of application may be obtained from the Institution of Mining and Metallurgy, Salisbury House, Finsbury Circus, London, E.C.2, and must be returned not later than March 1, 1954.

MOND NICKEL FELLOWSHIPS.—The Mond Nickel Fellowships committee invites applications for the award of Fellowships for 1954. The main object of these Fellowships is to enable selected applicants of British nationality and educated to University degree or equivalent standard, to obtain additional training and wider experience in industrial establishments, at home or abroad, so that, if they are subsequently employed in executive or administrative positions in the British metallurgical industries, they will be better qualified to appreciate the technological significance of research and to apply its results. There are no age limits, though awards will seldom be made to persons over thirty-five years of age. Each Fellowship will occupy one full working year and it is hoped to award five Fellowships each year of an approximate value of £900 to £1200 each. Applicants will be required to define the programme of training in respect of which they are applying for an award, as well as particulars of their education, qualifications and previous career. Full particulars and forms of application can be obtained from the Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1. Completed application forms will be required not later than June 1st next.

Personal and Business

MR. W. G. THOMAS has been appointed a director of Radiovisor Parent, Ltd., 1, Stanhope Street, London, N.W.1.

NORTHERN ALUMINIUM COMPANY, Ltd., states that the telephone number of its Leeds area sales office is now Leeds 33621.

BOWMAKER (PLANT), Ltd., Willenhall, Staffs, announces the appointment of Mr. J. M. Willson as works manager.

THE BRITISH BROADCASTING CORPORATION announces the appointment of Mr. H. O. Sampson as head of technical operations, television studios.

MELLOR BROMLEY AND CO., Ltd., Leicester, states that Mr. W. L. James has been appointed chairman in succession to the late Mr. H. R. Backhouse.

ENFIELD CABLES, Ltd., announces the following appointments:—Mr. J. E. Sunderland, director and general manager; Mr. M. J. Smith, technical director.

BROOKS AND WALKER, Ltd., states that its Kidderminster branch has been moved to 378, Stourbridge Road, Broadwaters, Kidderminster (telephone, Kidderminster 2016).

CHAMBERLAIN INDUSTRIES, Ltd., Staffa Works, Leyton, E.10, has made an agreement with Walter P. Hill, Inc., Detroit, Michigan, U.S.A., for the manufacture and sale outside the U.S.A. of Hill products.

INTERNATIONAL HARVESTER COMPANY, of Chicago, has made an agreement with The Heil Company, Milwaukee, which will enable it to manufacture Heil two-wheel industrial tractors for heavy construction work.

F. J. EDWARDS, Ltd., 359–361, Euston Road, London, N.W.1, states that it is now represented in Eire by Hendron Brothers (Dublin) Ltd., 37-39, Upper Dominick Street, Broadstone, Dublin (telephone, Dublin 41116).

FOLLSAIN-WYCLIFFE FOUNDRIES, Ltd., announces the following appointments of technical representatives: Scotland, Mr. W. Macfarlane, 134, St. Vincent Street, Glasgow, C.2; and Northern Ireland and Eire, Mr. J. Luke, 17, Adelaide Street, Belfast.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the appointment of Mr. T. W. J. Temple as manager of the Middlesbrough office in succession to Mr. G. Lloyd Jones, who is shortly taking up another appointment in the B.T.H. organisation.

COMMANDER (E) A. H. Robinson, R.N.V.R., ret., has been appointed London branch manager of Associated British Oil Engines (Marine), Ltd. Mr. K. Schwarz, London representative, is returning to the staff of the sales director at the company's head office at Ashton-under-Lyne.

ADAM MACHINE EQUIPMENT, Ltd., 4, Grange Street, St. Albans, Herts, has been formed to take over the United Kingdom agencies for Swiss and German high-precision machine tools and measuring equipment formerly handled by its parent company, Adam Machine Tool Company, Ltd.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., announces the appointment of Mr. R. B. Hill as manager of the cable sales department. Mr. W. M. Baxter has been appointed chief assistant manager of the cable sales department, and Mr. N. B. Frost has succeeded him as manager of the export cable sales division.

RALEIGH INDUSTRIES, Ltd., Nottingham, states that Mr. E. E. Baker, export sales director, has been appointed to the board. Mr. B. L. C. Dodsworth, company secretary, has been elected to the boards of all Raleigh subsidiary companies, and Mr. D. S. Robinson has been appointed a director of Sturmey-Archer Gears, Ltd.

CAMBRIDGE INSTRUMENT COMPANY, Ltd., 13, Grosvenor Place, London, S.W.1, announces the retirement of Mr. B. A. Robinson, M.I.E.E., representative for the past thirty-two years in the Newcastle upon Tyne area. Mr. Robinson, who has been in the company's service for forty-one years, is succeeded by his son, Mr. W. E. Robinson.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION states that Sir Clement Wakefield Jones, a part-time member of British Overseas Airways Corporation, is retiring at his own request on March 31st, when his term of office expires. Lord Rennell has accepted the Minister's invitation to join the board of B.O.A.C. in succession to Sir Clement.

NEWTON CHAMBERS AND CO., Ltd., Thorncliffe, Sheffield, has announced the appointment of three assistant managing directors, as follows:—Mr. P. J. C. Bovill (chemicals branch), Mr. S. C. Tyrrell (excavator branch), and Mr. K. E. Walker (engineering branch). Mr. R. F. A. Sampson, a local director and general sales manager of the chemicals branch, has been appointed London local director.

THE ROVER COMPANY, Ltd., announces the following appointments:—Mr. L. G. T. Farmer, assistant managing director; Mr. Allan Botwood, sales director; Mr. A. O. Hollick, personal assistant to the sales director; Mr. G. Lloyd Dixon, general sales manager; Mr. A. B. Smith, chief buyer; and Mr. C. Smith, secretary. Mr. E. G. Commander, who is retiring from the position of chief buyer after fifty-eight years in the company's service, has been appointed to the board.

British Patent Specifications

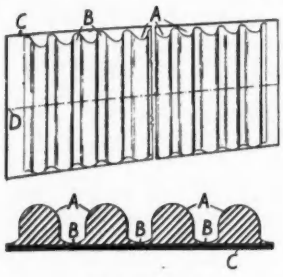
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

RAILWAY ENGINEERING

701,272. July 24, 1951.—BUFFERS AND FENDERS FOR RAILWAY WAGON TIPPLERS, The North British Rubber Company, Ltd., Castle Mills, Edinburgh 3, Scotland, and Robert McGowan, 15, Halmyre Street, Edinburgh 6, Scotland.

The object of the invention is to provide an improved buffer or fender which gives the necessary resiliency for high loads and considerably reduces the actual surface contact between the tippler and wagon with the result that the buffers last longer and give added protection to the wagon besides reducing risk of damage to the tippler. As will be seen from the drawing, the fender comprises a number of individual rubber buffers *A* of substantially semi-circular cross-section joined by a thin web of rubber *B*. The buffer



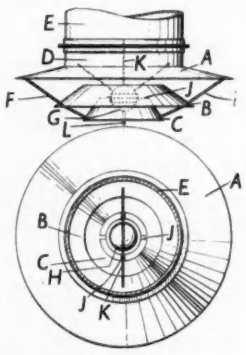
No. 701,272

assembly is vulcanised to the fabric base *C* to form the fender. The fender may be fixed by bolts or other suitable means to a side member of the tippler. The frame members of the tippler are provided with a substantial metal or wooden backing upon which the fender is mounted and on which it is secured by means of clamping strips positioned between the individual buffer members *A*. The back edges of the clamping strips which contact the thin web between the buffer members are preferably rounded so as to avoid cutting into the rubber when the securing bolts are tightened. In manufacturing the fenders, the individual buffers may be moulded singly or a number of them may be moulded together, joined by a relatively thin web of rubber and fixed by vulcanisation or moulded to a rubberised fabric or a metal base.—*December* 23, 1953.

FANS AND VENTILATORS

701,382. November 2, 1950.—VENTILATORS, Winsor Engineering Company, Ltd., Earl Haig Road, Hillington, Glasgow, S.W.2. (*Inventor: John Marshall.*)

The ventilator shown in the drawing consists of a diffuser having three frusto-conical rings *A*, *B* and *C* coaxially arranged and interspaced to form two diffusing passages, the diameters of the rings being successively reduced from the innermost to the outermost ring. The innermost ring has a cylindrical portion *D* connected to an inlet air supply conduit *E*, the rings being interconnected by stays *F*. The outermost ring has mounted at its inner end a ball and socket joint *G* located centrally of the ring *C*



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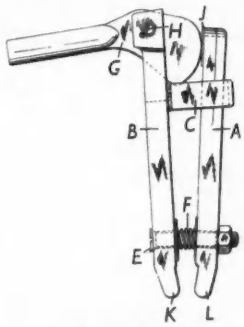
by stays *J*. A baffle *K* is connected to the inner portion of the ball and extends inwardly through the other two rings and an operating handle *L* is provided on the outer portion of the ball. By moving the handle, the baffle *K* can be swung transversely across the air flow entering the diffuser, and rotated about a longitudinal axis, and its position can thus be adjusted so that the general direction of the air passing through the diffuser can be altered as required. The baffle may be so shaped that, when it is moved as far as possible in any one direction, the flow of air in that direction is entirely cut off. It will, however, in general, suffice that the greater part of the air flow be redirected by the baffle when it is in any of its limit positions, as this avoids machining to fine limits, and any flow of air not redirected by the baffle would be so small as to be negligible.—*December* 23, 1953.

WORKSHOP TOOLS AND APPLIANCES

701,464. August 7, 1951.—CLAMP TOOL FOR ASSEMBLING RADIATOR SECTIONS, Crane, Ltd., 45–51, Leman Street, London, E.1 (*communicated by the Crane Company, 836, South Michigan Avenue, Chicago, U.S.A.*).

Referring to the drawing, it will be seen that the tool consists essentially of a plain jaw *A* and a jaw *B*, to which a handle is pivoted. The jaw *B* has a U-shaped parallel-sided guide member *C* welded to it. A cap screw *E* holds the jaws assembled, a spring *F* being interposed between the jaws as shown. A cam *G* is journalled within the recess of the bifurcated end of the jaw upon a pivot *H*, the cotter pins being used to



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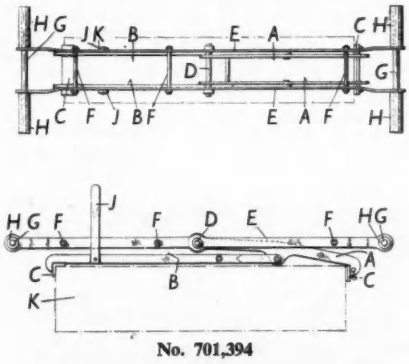
prevent accidental removal of the rod. In one position the cam is in part located within the confines of the guide member *C*. As illustrated, the transverse working edge of the cam normally bears against the pad *J* of the jaw *A*, and upon rotary movement of the cam upon the pivot the inwardly inclined work-engaging ends *K* and *L* of the jaws are either drawn together or spread apart, depending upon the direction of rotation of the cam. In the specification the tool is shown applied to a pair of assembled baseboard sections.—*December* 23, 1953.

CIVIL ENGINEERING

701,394. April 4, 1951.—DEVICE FOR LIFTING NARROW SLABS, William Rutherford, 11, Maple Avenue, Whitley Bay, Northumberland.

The invention consists of an improved device for lifting narrow slabs such as pavement kerbs without strain to the operators, and it may be readily adjusted so that for very heavy slabs three or more men may be employed. Referring to the drawing, *A* and *B* are two pairs of pincer-like arms similar to those described in Specification No. 645,790, arranged close together, the ends of which are secured to common gripping pads *C* and so form twin arms. The upper pair of arms is connected by a short transverse bar *D*, which projects beyond the pincer arms



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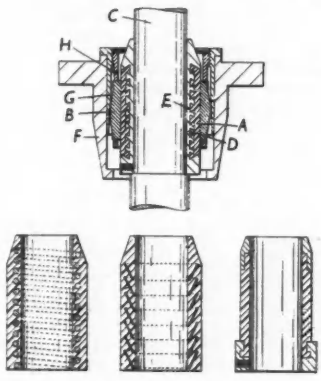
and passes into bores in the longitudinal members *E* of a rectangular frame in which it is pivotally mounted, the rectangular frame having a substantial clearance with the sides of the pincer arms. The frame members *E* are rigidly braced together by transverse bars *F* adjacent and intermediate their ends to form the complete frame, the members being splayed outwards to receive at the ends relatively long transverse bars *G* which provide handles for the operators. Rubber grips *H* are preferably arranged on the handles. On each of the lower pair *B* of the pincer arms there is rigidly secured a vertical guide or constraining member *J*, between which the rectangular frame *E* and *F* is located. These guide members serve to prevent the frame from being moved out of alignment with the pincer arms. In use the device is placed along and over the kerb *K* so that its jaws pass over the ends. An operator at each end grasps a transverse rod *G*. Both pull upwards and so grip the kerb. The raised kerb can then be transported to the desired site without difficulty, the vertical constraint members *J* maintaining the pincer arms *A* and *B* and the frame in correct relation so that any jolting will not affect the operation. The use of two or more devices to lift heavy slabs is also shown in the specification.—*December* 23, 1953.

BEARINGS AND SUPPORTS

701,508. November 1, 1949.—TILTING PAD BEARINGS, Hayward Tyler and Co., Ltd., Luton; Victor Ivanoff and Ralph Edward King, of the company's address.

The invention consists of a bearing of the tilting pad type in which the bearing surface engaging the pads is composed of synthetic resin material. Referring to the drawings, the inner element *A* of the bearing, which runs in the tilting metal pads *B*, is composed of phenol formaldehyde plastic material. Water is the



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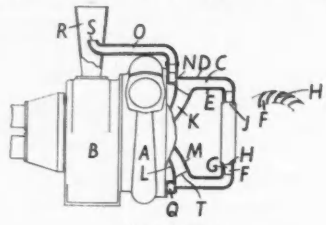
lubricant employed for the bearing. This plastic material takes the form of a sleeve mounted fast on a rotating metal shaft *C*, but as the plastic material absorbs liquid to a certain extent it swells a certain amount if means are not provided to prevent it, and this would be liable to cause the sleeve to become loose on the shaft. Also the swelling, if freely permitted, would necessitate a greater clearance between the sleeve *A* and the pads *B*. To avoid these difficulties the plastic material is keyed to a metal sleeve *D* mounted fast on the shaft. The material is moulded round the sleeve, which has a series of circular or a spiral groove *E*, which may be undercut. Alternatively, more designs are shown in the specification. In the particular arrangement shown the housing *F* of the bearing has its slightly coned inner periphery lined with a bush *G* and the pivot points of the tilting pads *B* engage this periphery. The tilting pads are located by means of a cage *H*, which is screwed at one end within the bush *G*. By rotatably adjusting the cage within the bush the cage, and therefore the pads *B*, are adjusted longitudinally and the tightness of the pads on the sleeve is adjusted.—*December* 30, 1953.

BLOWERS AND COMPRESSORS

701,470. October 1, 1951.—GAS BLOWERS AND COMPRESSORS, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

The invention relates to gas blowers and compressors, driven by gas turbines, which are provided at their gas inlets with devices for separating from the gases any solid or liquid particles which are suspended in the gases. As the drawing shows, the blower *A* is driven by an exhaust gas turbine *B* and is provided on the suction side with an annular channel *C*, which extends in the axial direction and is bounded by an outer casing surface *D* and an inner casing surface *E*. On the inlet side of this annular channel is a guiding device *F* consisting of a radial chamber *G* containing a ring of stationary guide blades *H*. These guide blades are of the radial flow type and impart a rotation to the air entering at *J*. After being set in rotation by the blades the air is deflected by 90 deg. at the transition from the radial chamber *G* into the axial annular channel *C*, so that particles of dust or moisture carried by the air are flung with considerable force against the outer casing surface *D*. The particles, together with the simultaneously rotating air, which moves with a helical

motion owing to the rotation imparted by the guiding device *F*, travel along the channel, pressed always by centrifugal force against the outer casing surface *D*. A sudden deflection of the air flow through approximately 90 deg. towards the axis of the blower is caused at the outlet end of the annular channel *C* by means of an adjoining channel *K*, defined by boundary surfaces *L* and *M*. The particles, by reason of their greater inertia, continue to move in the original direction along the outer casing surface *D* and there-



No. 701,470

fore pass through an annular aperture *N* into an annular collecting chamber *Q*, and from there pass through a pipe *O* which connects the collecting chamber *Q* with the outlet *R* from the exhaust gas turbine, so that the particles of dust or moisture arriving in the collecting chamber from the annular channel are continuously sucked away by the extractor effect of the exhaust gases flowing from the turbine past the outlet *S* from the pipe. Alternatively, instead of the annular escape aperture *N*, several escape apertures could be provided, for example, an annular aperture subdivided by partitions. In this case each aperture could lead to a separate collecting chamber. The particle-free air in the channel *K* is conducted by guide blades *T* into the blower.—*December* 23, 1953.

Codes of Practice

The Council for Codes of Practice for Buildings has now issued in final form Code 304 (1953): "Soil and Waste Pipes Above Ground." It deals with the design and installation of sanitary plumbing systems, i.e. internal and external soil, waste and ventilating pipes above ground level, but not with rainwater pipes. Section 3: "Design Considerations," contains details of the various systems in use and gives recommendations as to the general layout and the design of pipe sizes and gradients to carry the discharges from various combinations of sanitary appliances. The section devoted to "work on site" consists of practical recommendations for the installation of plumbing waste systems. Copies may be obtained from the British Standards Institution, 2, Park Street, London, W.1, price 6s.

Launches and Trial Trips

ÍMERINA, passenger and cargo ship; built by the Ateliers et Chantiers de Provence for the Messageries Maritimes; length overall 378ft, length between perpendiculars 359ft 5in, breadth 52ft 10in, depth to upper deck 29ft 3in, draught 19ft 8in, deadweight 4200 tons, service speed 14 knots; twelve cabin passengers, twenty deck passengers, 350 steerage passengers; two complete decks, seven water-tight compartments; nine derricks including one of 30 tons; Creusot-B. and W. diesel engine, five cylinders, 620mm diameter by 1150mm stroke, 3000 b.h.p.; three 180kW diesel-driven generators. Trial, December.

SHIP No. 237, oil tanker; built by John Crown and Sons, Ltd., for Rolf Wigand Skipsrederi, Norway; length between perpendiculars 516ft, breadth moulded 73ft, depth moulded 41ft 1in, deadweight 18,250 tons on 30ft 6in draught; North-Eastern Marine-Sulzer single-acting, two-stroke diesel engine, nine cylinders, 720mm diameter by 1250mm stroke, 6300 b.h.p. at 125 r.p.m., speed 14·5 knots. Launch of fore part of ship, January 5th.

LANGUEDOC, oil tanker; built by the Ateliers et Chantiers de la Seine-Maritime for the Société Francaise des Transports Petroliers; length between perpendiculars 538ft 1in, breadth moulded 73ft 8in, depth 40ft 6in, draught 30ft 6in, deadweight 19,500 tons; twenty-four cargo oil tanks, two pump-rooms, three 150kW diesel-driven generators, one 60kW steam-driven generator; one six cylinder Doxford oil engine, 7300 b.h.p. at 115 r.p.m.—Trial, January.

A TRENCH HOE ATTACHMENT.—The Allis-Chalmers "Tracto-Shovel," now being imported into this country by Mackay Industrial Equipment, Ltd., is fitted with a standard 1 cubic yard bucket, and can be used to excavate, load and bulldoze materials. A trench hoe attachment is interchangeable with the standard bucket attachment of the "Tracto-Shovel." To fit the hoe the bucket and dump links are detached by removing four pins, which are then used to attach the trench hoe to the lift arms. In addition, two pins are used to affix the tubular boom of the hoe to two supporting lugs welded on top of the lift arms. With the hoe equipment the machine can be used to excavate a trench 8ft deep and 27in wide. The standard trench hoe bucket is fitted with six teeth and has a capacity of ½ cubic yard.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Jan. 26th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Microwave Measuring Instruments," P. M. Ratcliffe, 7.15 p.m.

Thurs., Feb. 4th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Electronics in Film Making," W. D. Kemp and B. R. Greenhead, 7 p.m.——N.W. SECTION: Reynold's Hall, College of Technology, Sackville Street, Manchester, 1, "Police Radio, its Past, Present and Future Possibilities," I. Auchterlonie, 7 p.m.——MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, 1, "Micro-wave Test Gear," J. Bilbrough, 7 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Feb. 1st.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Operation of Soaking Pits," J. Dodd, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Feb. 2nd.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, Open Forum, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "The Efficiency of a Modern Steam Plant," H. E. Partridge, 7 p.m.

Wed., Feb. 3rd.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Heat Pumps," Oliver Lyle, 7.30 p.m.

Thurs., Feb. 4th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Feed Water Treatment," Hector Taylor, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 27th.—LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, "Cast Iron Apropos Enamelling," A. Adam, 7.30 p.m.

INSTITUTE OF FUEL

Tues., Jan. 26th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Refractory Recuperators," F. H. Cass, N. L. Franklin and A. L. Roberts, 5.30 p.m.

INSTITUTE OF METALS

Tues. Feb. 2nd.—OXFORD LOCAL SECTION: Cadena Café, Cornmarket Street, Oxford, Junior Members Evening, Discussion on New Topics, 7 p.m.

Thurs., Feb. 4th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Fracture of Steel," J. E. Russell, 6.30 p.m.——LONDON LOCAL SECTION: 4, Grosvenor Gardens, S.W.1, "Germanium and Silicon," R. W. Douglas, 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Jan. 26th.—N.E. OF ENGLAND GROUP: Royal County Hotel, Durham City, "Thin Wall Bearings," P. Holligan, 7 p.m.

INSTITUTE OF WELDING

Thurs., Feb. 4th.—N. LONDON BRANCH: Manson House, Portland Place, W.1, "Avoiding Fatigue in Welded Structures," R. Weck, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Feb. 16th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Mechanisation of Bracken Eradication," G. Henderson, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Jan. 30th.—MIDLANDS BRANCH: The University, Edmund Street, Birmingham, Annual General Meeting, "Some Aspects of Biochemical Engineering," B. Edgington, 2.30 p.m.

Tues., Feb. 2nd.—Geological Society, Piccadilly, London, W.1, "Sedimentation and Fluidisation," J. F. Richardson and W. N. Zaki, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 26th.—HYDRAULICS MEETING: Great George Street, Westminster, London, S.W.1, "Rainfall, Run-off and Storage—Elan and Claerwen Gathering Grounds," C. A. Risbridger and W. H. Godfrey, 5.30 p.m.

Wed., Jan. 27th.—N.W. ASSOCIATION: Reynold's Hall, College of Technology, Manchester, "Site Exploration," E. Morton, 6.30 p.m.

Fri., Jan. 29th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield, "Weakness of Cast Iron in Tension, with reference to Six Shaft Sinking Accidents, 1905–52," I. C. Easton, 7 p.m.

Tues., Feb. 2nd.—MARITIME MEETING: Great George Street, Westminster, London, S.W.1, "Site Exploration for Maritime and River Works," M. J. Tomlinson, 5.30 p.m.——N.W. ASSOCIATION: Reynold's Hall, College of Technology, Manchester, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.45 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 25th.—RADIO SECTION: Savoy Place, London, W.C.2, Discussion on "Should Sound Broadcasting of the Future be Entirely in the V.H.F. Band?" opened by A. J. Biggs, 5.30 p.m.

Mon., Feb. 1st.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "A Recent Application of Diesel-Electric Propulsion," P. W. R. Gatliff; "Some Aspects of the French Distribution System" K. Shaw; "The Production and Testing of Transistors," J. Hughes, 6 p.m.

Tues., Feb. 2nd.—MEASUREMENTS AND SUPPLY SECTIONS: Savoy Place, London, W.C.2, "Measurement of the Winding Resistances of a 132kV Power Transformer in Service," K. J. R. Wilkinson and J. D. Harmer, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "The Testing and Specification of Bushings in Relation to Service Conditions," H. Barker and H. Davies, 6.30 p.m.

Wed., Feb. 3rd.—S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Industrial Switchgear," K. M. Street, 7 p.m.

Thurs., Feb. 4th.—ORDINARY MEETING: Savoy Place, London, W.C.2, "The Manchester-Kirk o' Shotts Television Radio Relay System," G. Dawson, L. L. Hall, K. G. Hodgson, R. A Meers, and J. H. H. Merriman, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 26th.—39, Elmbank Crescent, Glasgow, "Research in Marine Auxiliary Machinery," S. Weinberg, 6.45 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Thurs., Feb. 4th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, Film Evening, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 22nd.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "On the Graphical Solution of Transient Vibration Problems," R. E. D. Bishop, 5.30 p.m.

Tues., Jan. 26th.—EASTERN BRANCH: C.U. Engineering Laboratories, Cambridge, "Relaxation Methods: A Retrospect," Sir Richard Southwell, 8.15 p.m.

Wed., Jan. 27th.—APPLIED MECHANICS GROUP DISCUSSION: Storey's Gate, St. James's Park, London, S.W.1, "Glands and Seals for Rotating Shafts," 6.45 p.m.

Mon., Feb. 1st.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, "High-Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.

Tues., Feb. 2nd.—COVENTRY BRANCH: Craven Arms Hotel, High Street, Coventry, Address by Centre Chairman, Leonard Griffiths, 7.15 p.m.

Wed., Feb. 3rd.—INTERNAL COMBUSTION ENGINE GROUP DISCUSSION: Storey's Gate, St. James's Park, London, S.W.1, "The Extent to which the Gas Turbine May Supplant or Supplement the Piston Engine in the Next Ten or Twenty Years," 6.45 p.m.——SOUTHERN BRANCH: Technical College, Maidstone, "History of Patents," R. E. Tree. (No time given.)

Thurs., Feb. 4th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Steelwork Engineering with Particular Reference to Continuous Strip Mills," R. L. Willott, 6.45 p.m.

INSTITUTION OF MINING ENGINEERS

Thurs., Jan. 28th.—Connaught Rooms, Great Queen Street, London, W.C.2, Annual General Meeting, 11.15 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Jan. 25th.—MANCHESTER SECTION: Reynold's Hall, College of Technology, Manchester, "Printing Machine Construction and Functioning," R. Hall, 7.15 p.m.

Tues., Jan. 26th.—COVENTRY SECTION: Geisha Café, Hertford Street, Coventry, "Recent Developments in Metal Machining," K. J. B. Wolfe, 7 p.m.——LUTON SECTION: Small Assembly Room, Town Hall, Luton, "Hat Manufacture," D. A. Bagni, 7.15 p.m.

Wed., Jan. 27th.—SHREWSBURY SECTION: Technical College, Shrewsbury, "Spheroidal Graphite Cast Iron," A. B. Everest, 7.30 p.m.

Thurs., Jan., 28th—CORNWALL SECTION: Camborne School of Mines, Camborne, Cornwall, "Some Notes on the Technique of Casting Aluminium Alloy Billets by the Continuous Casting Process," E. Mitchison, 7.15 p.m.

Tues., Feb., 2nd.—PETERBOROUGH SECTION: Campbell Hotel, Bridge Street, Peterborough, "Design for Welding," 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., Jan. 28th.—11, Upper Belgrave Street, London, S.W.1, "Design and Construction of a Welded Portal Frame Warehouse Building Designed by the Plastic Method," E. J. Callard, 6 p.m.

Tues., Feb. 2nd.—Cleveland Scientific and Technical Institution, Corporation Street, Middlesbrough, "Prestressed Concrete in Civil Engineering Works," A. J. Harris, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 22nd.—INFORMAL MEETING: Townsend House, Greycoat Place, London, S.W.1, "Some Aspects of the Issue of Technical Information to Industry," J. C. Y. Baker, 7 p.m.

Mon., Jan. 25th.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, "Flour Milling Plant," L. T. Ansley, 7.30 p.m.

Fri., Jan. 29th.—INFORMAL MEETING: Townsend House, Greycoat Place, London, S.W.1, "Wheel Equipment with particular reference to Aircraft," C. D. Holland, 7 p.m.

Wed., Feb. 3rd.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Sintered Component Manufacture," B. H. Swann, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Jan. 27th.—24, Dale Street, Liverpool, "The Development of Industrial Gas Turbines," G. B. R. Feilden, 6 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Jan. 22nd.—Engineers' Club, Albert Square, Manchester, "A Geared Diesel Whale Catcher," F. Brooks, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 29th.—Mining Institute, Newcastle upon Tyne, "Stress Investigation on a Tanker During Launching," A. J. Johnson and M. Meek, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Feb. 2nd.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.45 p.m.

Wed., Feb. 3rd.—N.W. BRANCH: Liverpool Engineering Society, 24, The Temple, Dale Street, Liverpool, "Load Factor Design in Reinforced Concrete," F. G. Thomas, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 26th.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "X-Ray Metallography," G. L. J. Bailey, 7 p.m.

Thurs., Feb. 4th.—4, Hamilton Place, London, W.1, "Air Intake Efficiency," F. B. Greatrex, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Feb. 1st.—Geological Society, Burlington House, Piccadilly, London, W.1, Presidential Address, W. R. Howard, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Jan. 26th.—Manson House, Portland Place, London, W.1, Discussion on "Kinematic Design," opened by H. J. Braddick, 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Jan. 27th.—MANCHESTER BRANCH: "The Manufacture of Forged Steel Railway Wheels," E. J. White, 6.45 p.m.